AGRICULTURAL ENGINEERING FOR EXTENSION WORKERS

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Agricultural Engineering for Extension Workers is one of a series of text books planned by the Directorate of Extension, Ministry of Food and Agriculture, Government of India, primarily for the use of instructors and Gram Sevak trainees in the Extension Training Institutions working under the guidance of the Directorate. The information contained in these books is based on scientific research and practical experience, and will, it is hoped, be of use to the general farm reader as well.

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M. G. Kamath

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FOREWORD

The Indian farmer is traditionally a hard worker, but his hard work seldom brings him a rich harvest because of his not adopting modern farming practices. Among these, the use of simple implements and tools which save labour and also create conditions for the better germination, growth and yield of crops, is important. It is this field of agricultural development that needs greater attention.

To the average Indian farmer, any implement that he cannot understand about or which he or the village blacksmith is not able to manipulate, is naturally a taboo. As such, the implements and tools meant for his farm should not only be cheap but also be simple to operate and repair. Research in the field of agricultural engineering has brought forth new and simple implements, and improvements in the existing ones. These new implements and improvements will readily appeal to the farmer, and it is the Extension worker who has to popularize them in our villages. A book which deals with all these implements suitable for utilization in big as well as small farms, and which are suited to the various agro-climatic conditions of the country, is, therefore, very welcome.

I was very happy to go through this compilation by Shri D. N. Kherdekar, who will earn the gratitude of our farmers and Extension workers for providing in these pages valuable information in a simple and non-technical language on the various implements and tools meant for everyday farm use and also for the various subsidiary occupations on the farm. He has not forgotten the bigger machinery for use by cooperatives and farmers with large holdings. Shri Kherdekar has also made it easy for the layman to grasp the subject by providing a large number of photographs and illustrations.

"Agricultural Engineering for Extension Workers" will surely be a landmark in the literature for farm people and Extension workers in our country.

M. V. KRISHNAPPA
Deputy Minister for Agriculture
Ministry of Food & Agriculture

1st October, 1959
New Delhi

PREFACE

Farm implements are in use in India since ancient times. Besides the plough and its accessories, of which detailed descriptions are given in books like the Krishi-Samagrah of Parasara and the Amarkosa, the sickle (*srni*), the hoe (*khanitra*), the harrow (*kotisa*), the winnowing appliances (*surpa* and *dhanyakrt*), etc., have also been in use since remote times. These have come down to us almost unchanged. But agricultural implements, like all other tools which man has invented for his comfort and progress, are conditioned by his economic needs. Until these needs grow complex, the tools have not to be modified much. Under the stress of modern conditions when speed and larger production are the need of the times, technological changes have to progress fast, and the farmer, like the artisan, has to depend more and more on the ever-evolving machines for his efficiency.

Kherdekar's book is as opportune as it is useful. Under the Extension programme a big effort is being made to modernize Indian agriculture. For this the Village Level Worker, who is the key-man in the scheme, has to be equipped with all the necessary knowledge. Kherdekar's book is a part of this equipment. It provides a good deal of information on agricultural implements and machines which would suit the requirements of the small farmers as well as of the larger holders in the different agro-climatic regions of the country. Its range is wide, covering the implements of tillage, irrigation, harvesting and processing, plant protection, subsidiary farm industries, etc. The book will no doubt be valued as a useful compendium by the Extension worker as well as the progressive farmer. The treatment of the subject is simple, and has been made all the more effective with the help of a large number of illustrations. I compliment the author for the labour he has expended on the work.

M. S. RANDHAWA D.SC., I.C.S.
Vice-President
Indian Council of Agricultural Research

7th October, 1959
New Delhi

INTRODUCTION

Agricultural Engineering deals with farm implements, farm structures, farm machinery and allied branches. While the farms in the Western countries are highly mechanised employing intricate power-driven machinery, we, in India, still have to depend on manual or bullock-driven implements. This is mainly because of the small holding of an average Indian farmer and his limited financial resources, which make it impossible for him to go in for big machines.

For these reasons, the Extension worker has mainly to deal with improvements in simple agricultural implements like ploughs, cultivators, harrows, plant protection equipment and equipment necessary for bee-keeping, poultry, etc. He has also to have some knowledge of the construction of simple roads and sanitary structures and home appliances suitable for adoption in villages. The reader will find that more stress has been laid on such implements and appliances in this book. Similarly, oil engines, tractors, pumps and other modern agricultural machinery suitable to Indian conditions, which are fast becoming popular with our farmers, have also been given due emphasis.

Agricultural Engineering is essentially a practical subject. Merely theoretical knowledge will not carry an Extension worker very far in this sphere. He should, therefore, try to learn things by actually doing them with his own hands. An hour spent in the workshop or in the field with a wrench and a hammer will lead to better results than two hours spent in the classroom.

It is suggested that Instructors in Agricultural Engineering should freely use appropriate sketches and diagrams while explaining the construction and operation of agricultural implements. It is easier to understand a good sketch than a lengthy description. Use of sectional working models may also be made while giving lessons to the trainees so that they can understand how different machines are constructed and how they work.

An Extension worker should not hold a biased view that only simple and primitive machines are useful in India or that all the big machines used in the West are useful here. It is hoped that this book will impart to him a balanced outlook on the application of the knowledge of Agricultural Engineering to Indian agriculture.

25th September, 1959
New Delhi

D. N. KHERDEKAR

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CHAPTER 1

ARTISAN'S TOOLS AND THEIR USES

Carpenters, blacksmiths, tinsmiths and fitters use a large number of hand-tools while repairing and manufacturing improved agricultural implements. Some of these are required for common use and are normally kept by efficient farmers who own agricultural machinery. The Village Level Workers should know the general use of at least some of the hand-tools which are required for the maintenance of agricultural machinery.

The uses of some important hand-tools are described below.

1. HAMMERS, which are of five types, are used for different purposes.
   a. Ball-peen hammers are used for rivetting.
   b. Straight-peen and cross-peen hammers are used for swaging.
   c. Claw hammers are used by carpenters for driving in or pulling out nails.
   d. Sledges are heavy hammers used by blacksmiths for forming steel.
   e. Soft hammers or mallets are used by tinsmiths to give shape to sheet metal.

2. VICES are used for holding the work while it is being finished or assembled. There are three types of vices, namely a carpenter's vice, a blacksmith's vice and a fitter's vice.

3. HACK-SAWS are used for cutting steel.

4. COLD CHISELS are used for shaping, chipping and cutting thin sheet metal.

5. CENTRE PUNCHES are used to mark locations for drills.

6. SCRIBERS are used for marking lines in measuring or in lay-out work.

7. WRENCHES are used for tightening or loosening nuts and bolts or pipes. Wrenches are single ended, double ended and closed ended. There are special types of wrenches

also, such as a socket wrench, an offset wrench and a ratchet wrench. These are used where nuts are almost inaccessible as in engines. The Stillson pipe wrench and the chain pipe wrench are used for turning pipes and pipe joints. An adjustable monkey wrench is a very useful instrument and at least a pair of these is maintained in a good workshop.

8. PLIERS are used for cutting wire and for holding the machine parts. This is also a very useful tool.

9. SCREW DRIVERS are used for fixing and taking out screws.

10. HAND DRILLS are used for boring holes either in steel or in wood. The required size of a drill-bit or a countersunk bit is fixed in the drill chuck before the drill is used.

11. TAPS AND DIES are used for producing threads inside a nut or on the outside of a bolt.

12. MICROMETERS accurately measure the thickness of material. In precision engineering, they are very useful.

13. BOXWOOD FOLDING RULES are used for measuring wood.

14. STEEL SQUARES are used for measuring and squaring work in carpentry.

15. IRON PLANES are used for levelling wood.

16. MARKING GAUGES are used for drawing parallel lines.

17. HAND SAWS are used for cutting and a COMPASS SAW is used for making circular holes.

18. FLAT WOOD-CHISELS are used for cutting slots in wood.

19. AUGER BITS are used for drilling big-sized holes in wood.

20. DIVIDERS are used for measuring and for scribing circles and arcs.

21. INNER AND OUTER CALLIPERS are used for measuring the inside and outside diameters of tubes and rods.

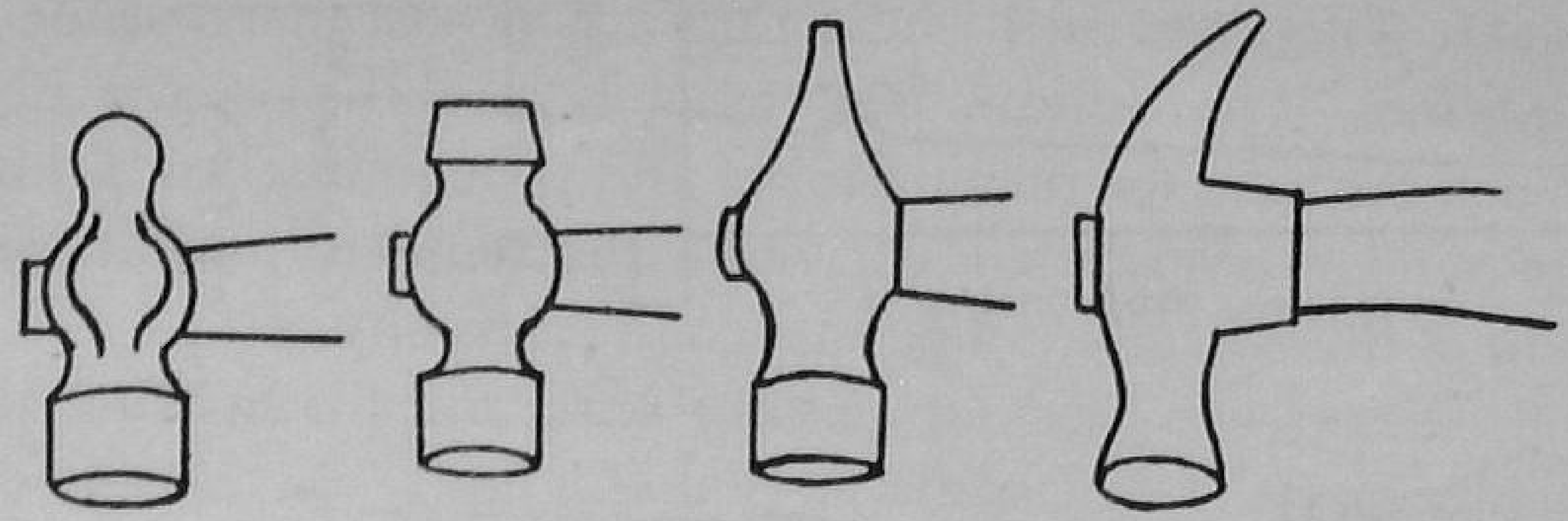
22. TINNER'S SNIPS are used for cutting thin sheet metal.

23. SQUARE-POINTED COPPERS AND BOTTOMING COPPERS are used for soldering.

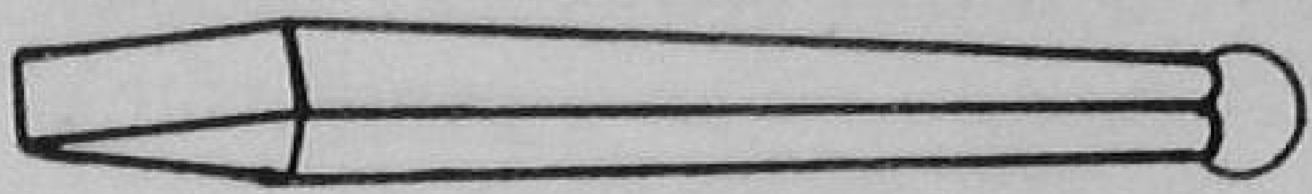
24. FILES AND RASPS are used for filing and rounding work.

25. FORGES are used for heating and forming iron and steel.

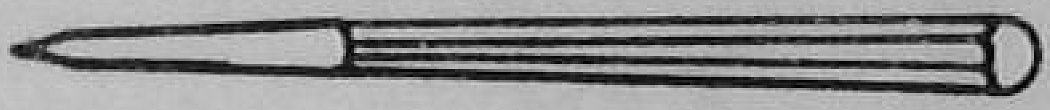
26. ANVILS are used for forming hot or cold steel. In conjunction with the forge and the anvil, fullers, swages and swage blocks, and poker are also used.



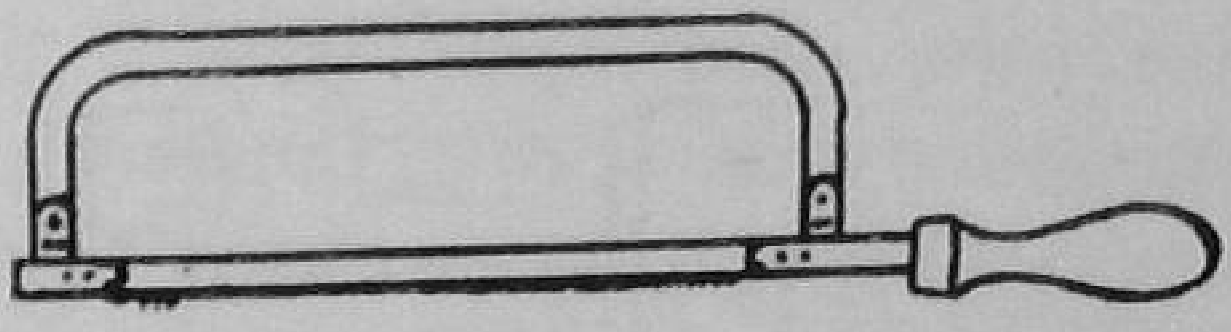
HAMMERS



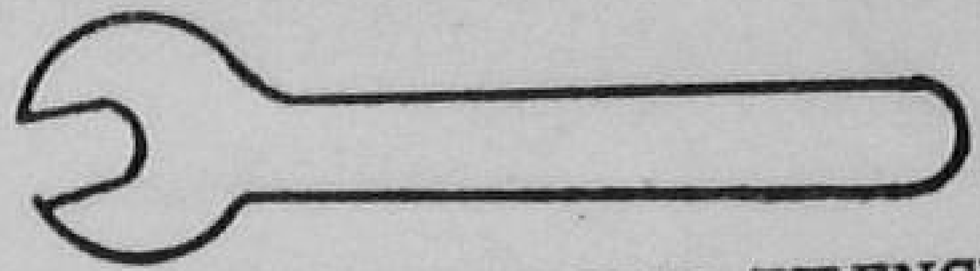
COLD CHISEL



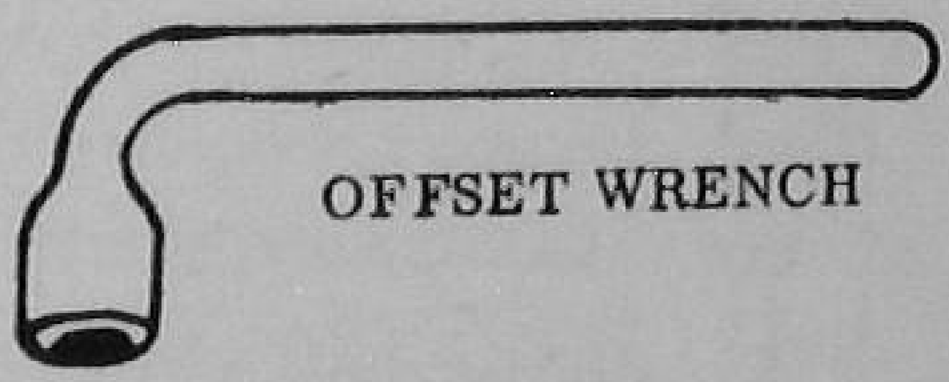
CENTRE PUNCH



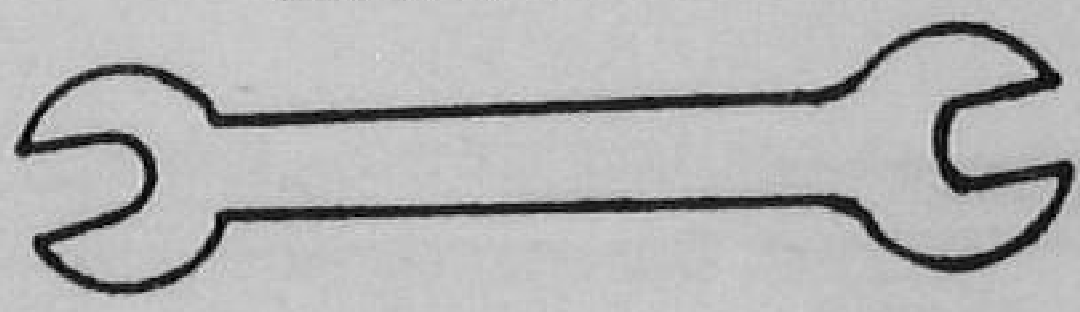
HACK SAW



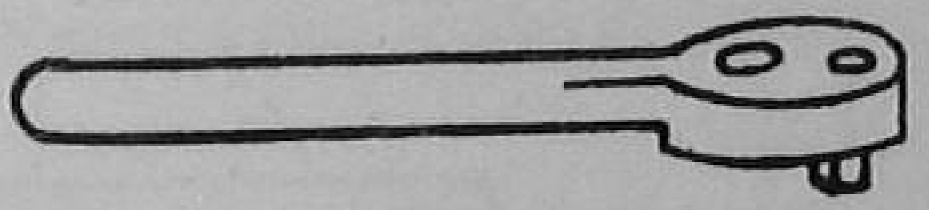
SINGLE ENDED WRENCH



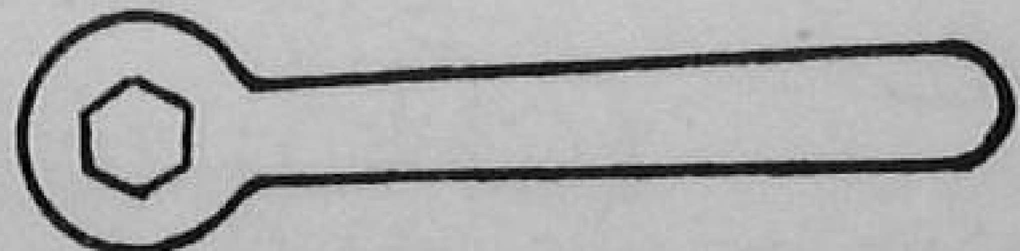
OFFSET WRENCH



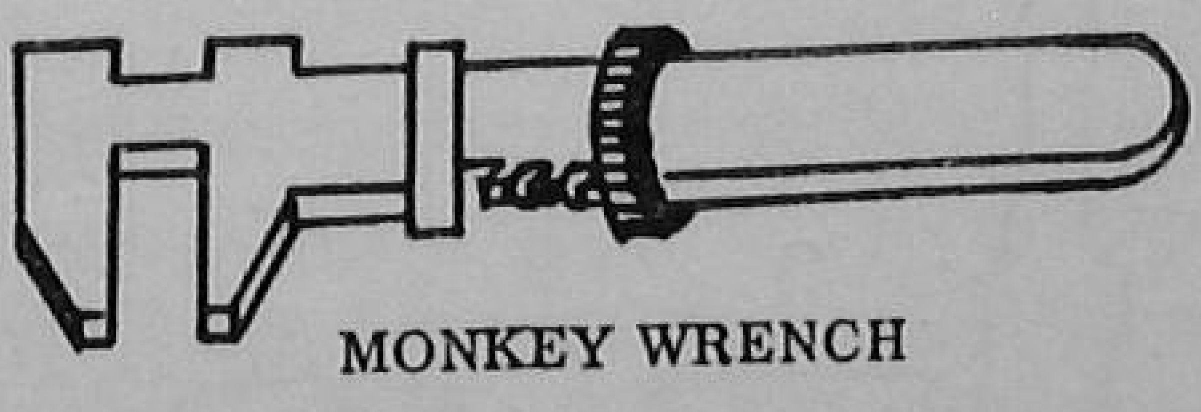
DOUBLE ENDED WRENCH



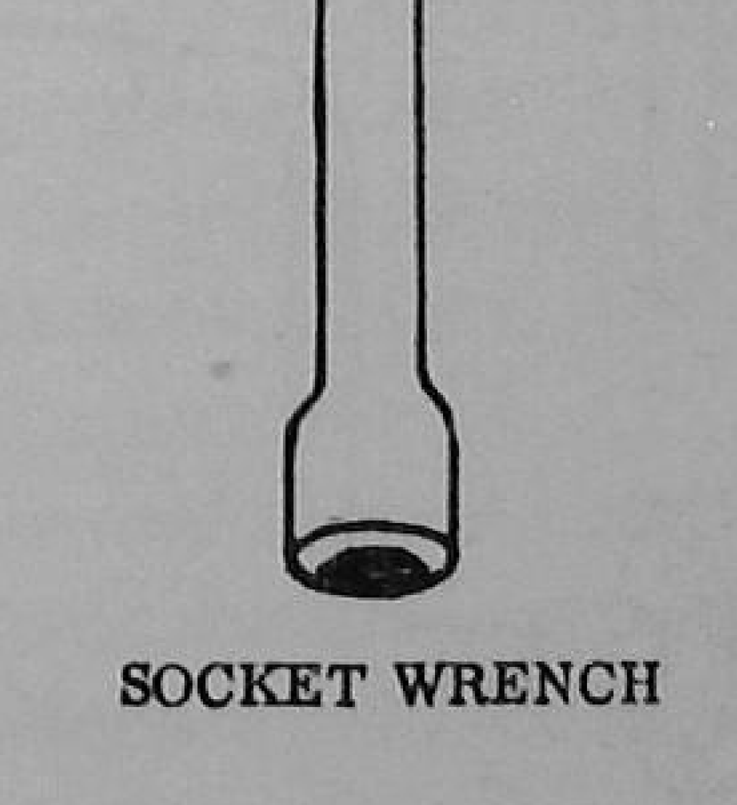
RATCHET WRENCH



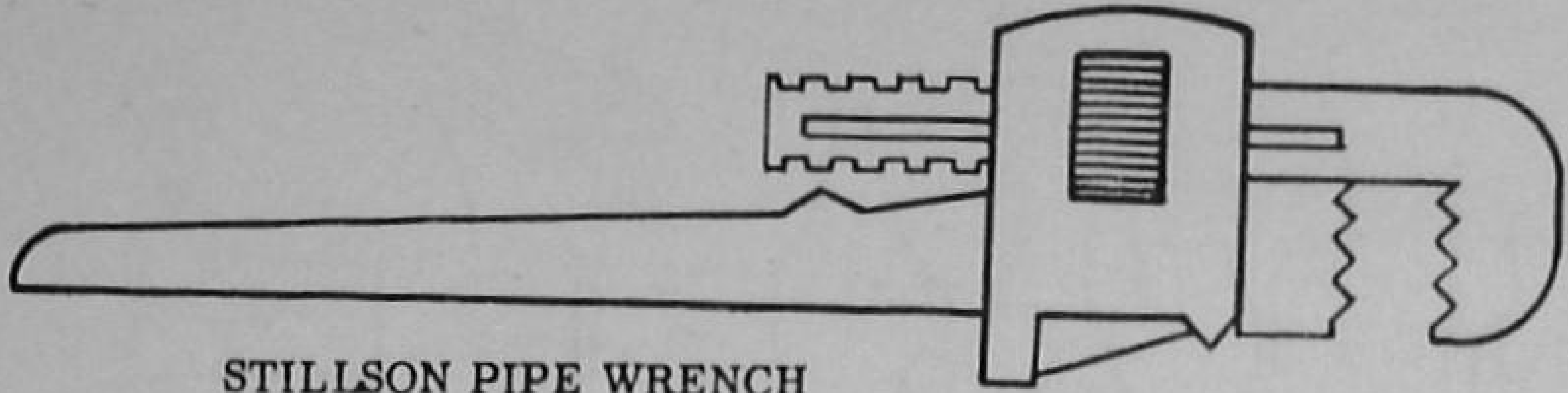
CLOSED ENDED WRENCH



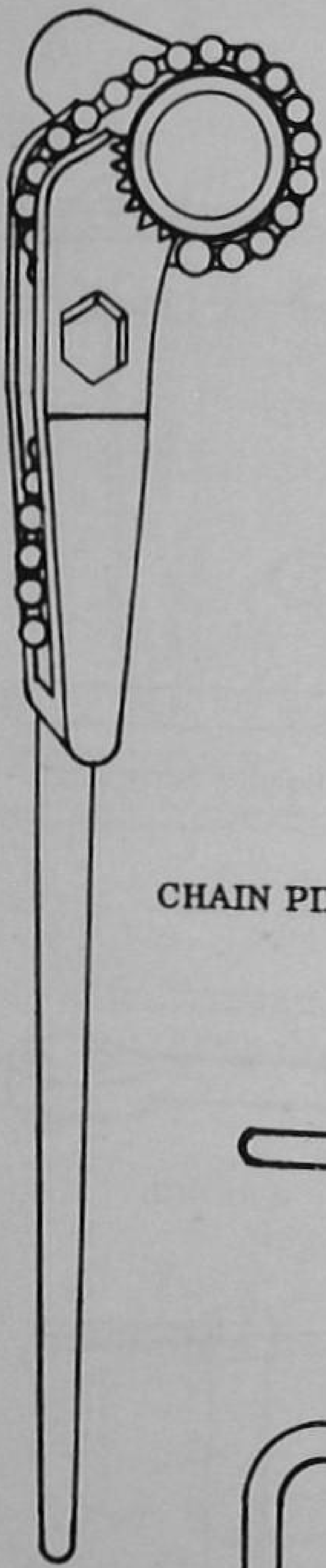
MONKEY WRENCH



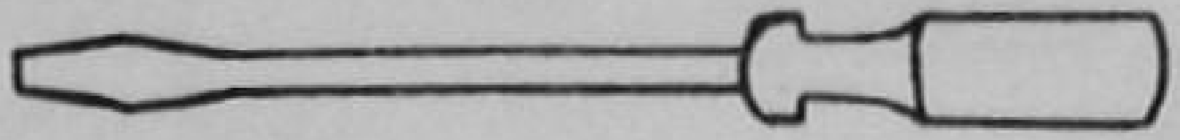
SOCKET WRENCH



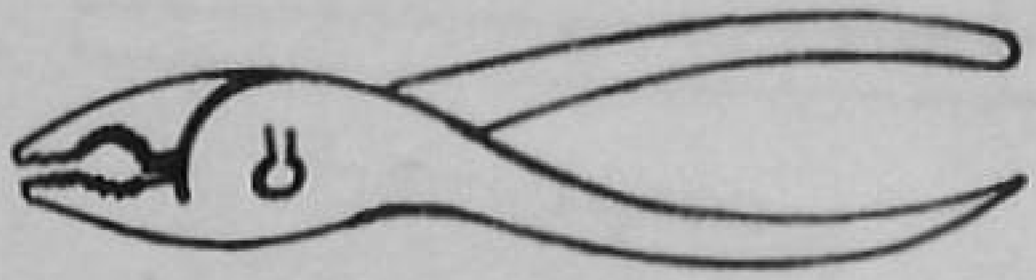
STILLSON PIPE WRENCH



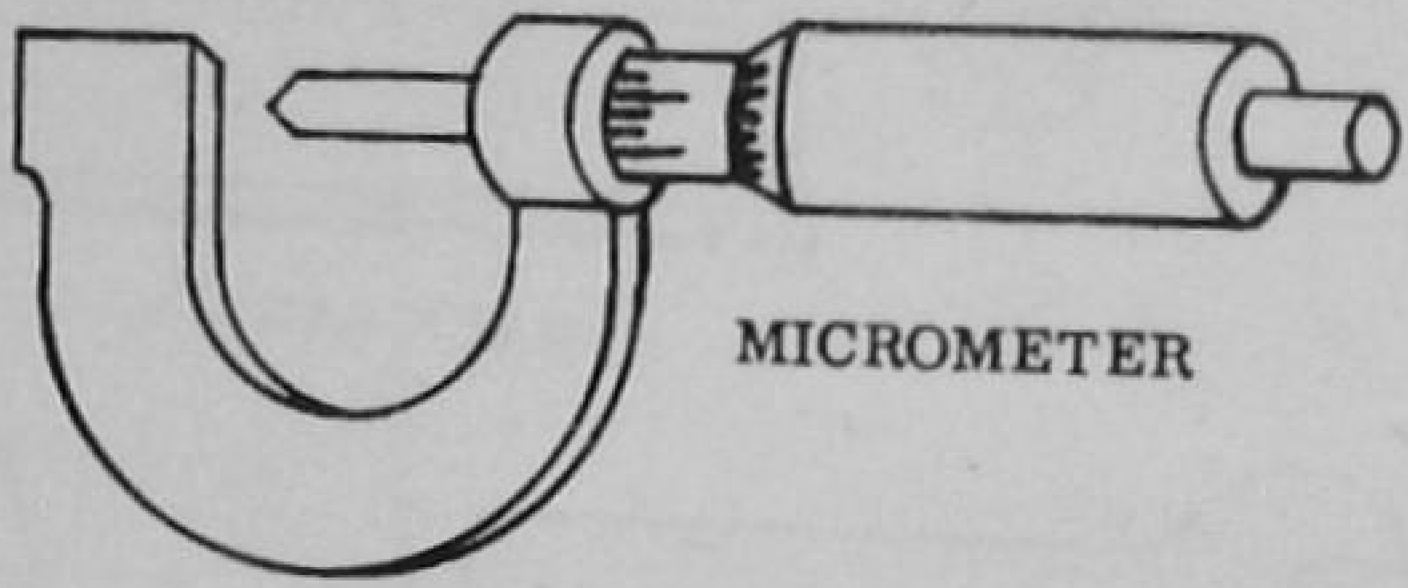
CHAIN PIPE WRENCH



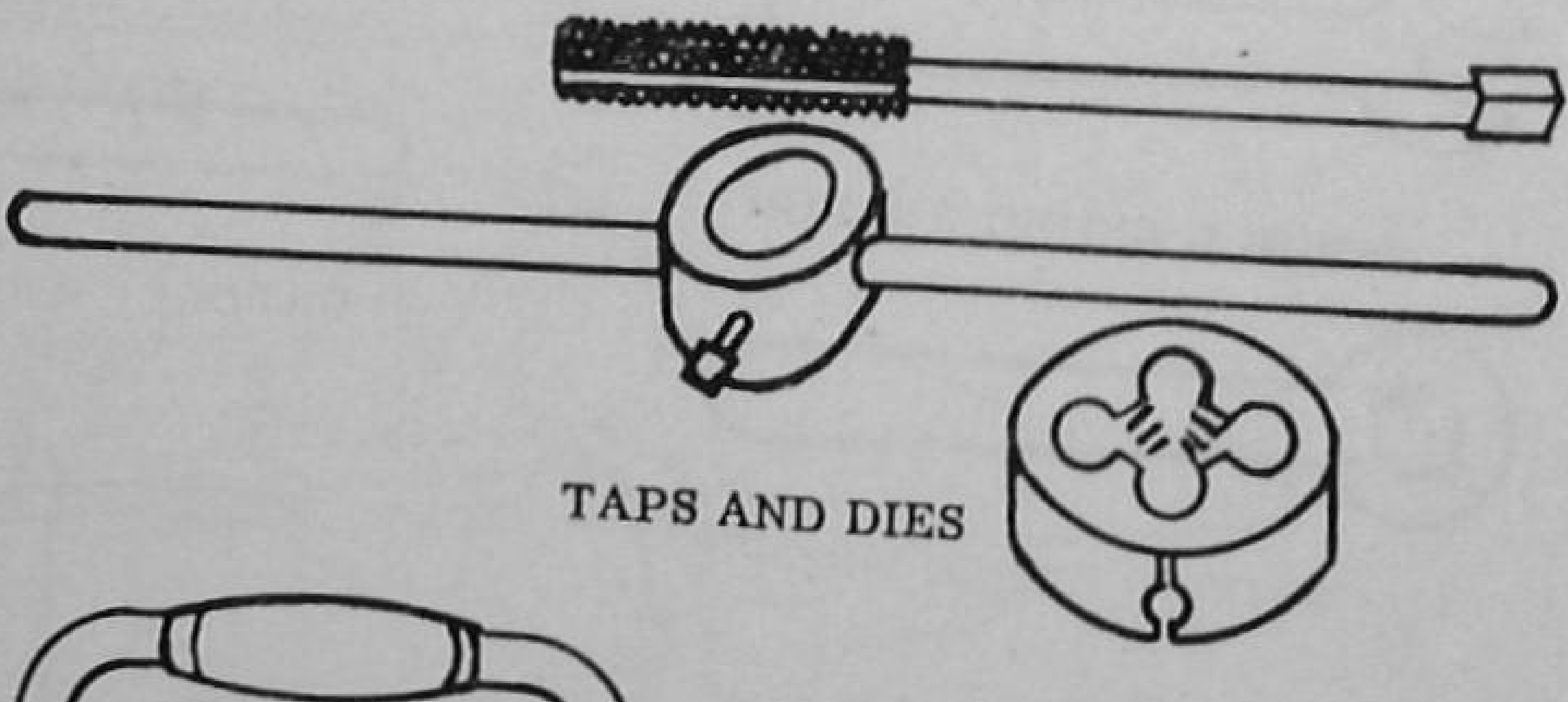
SCREW DRIVER



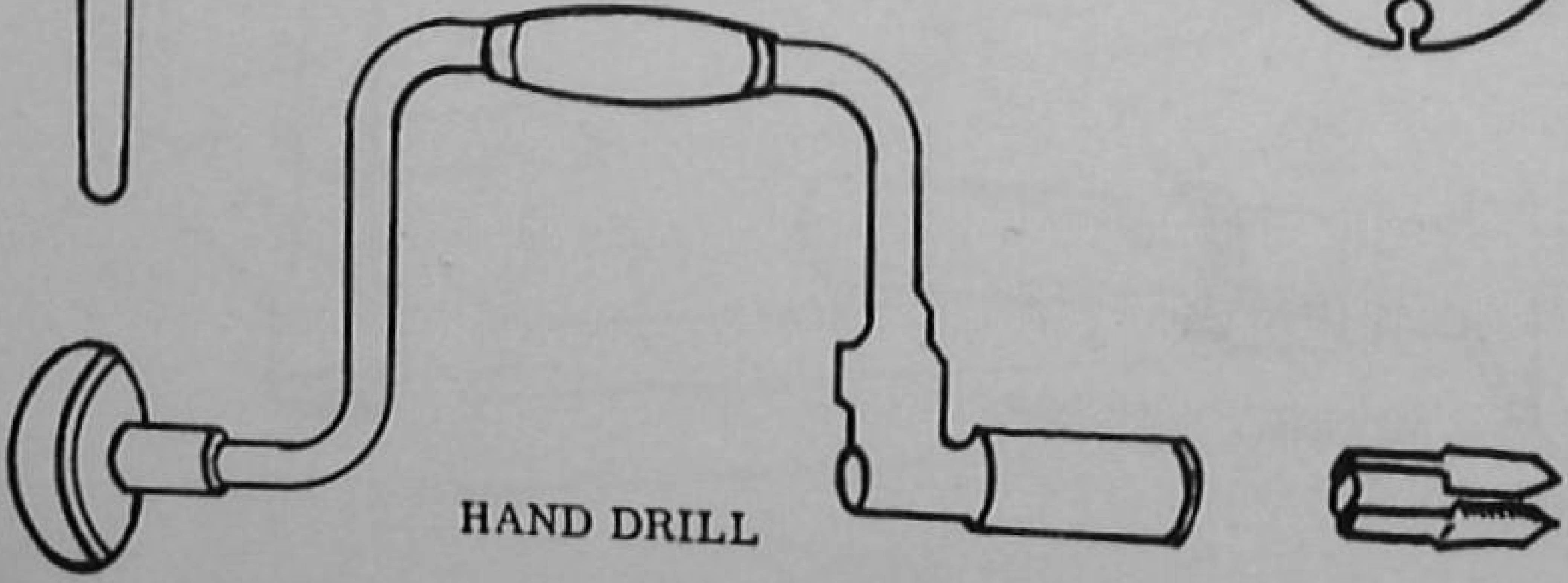
PLIERS



MICROMETER

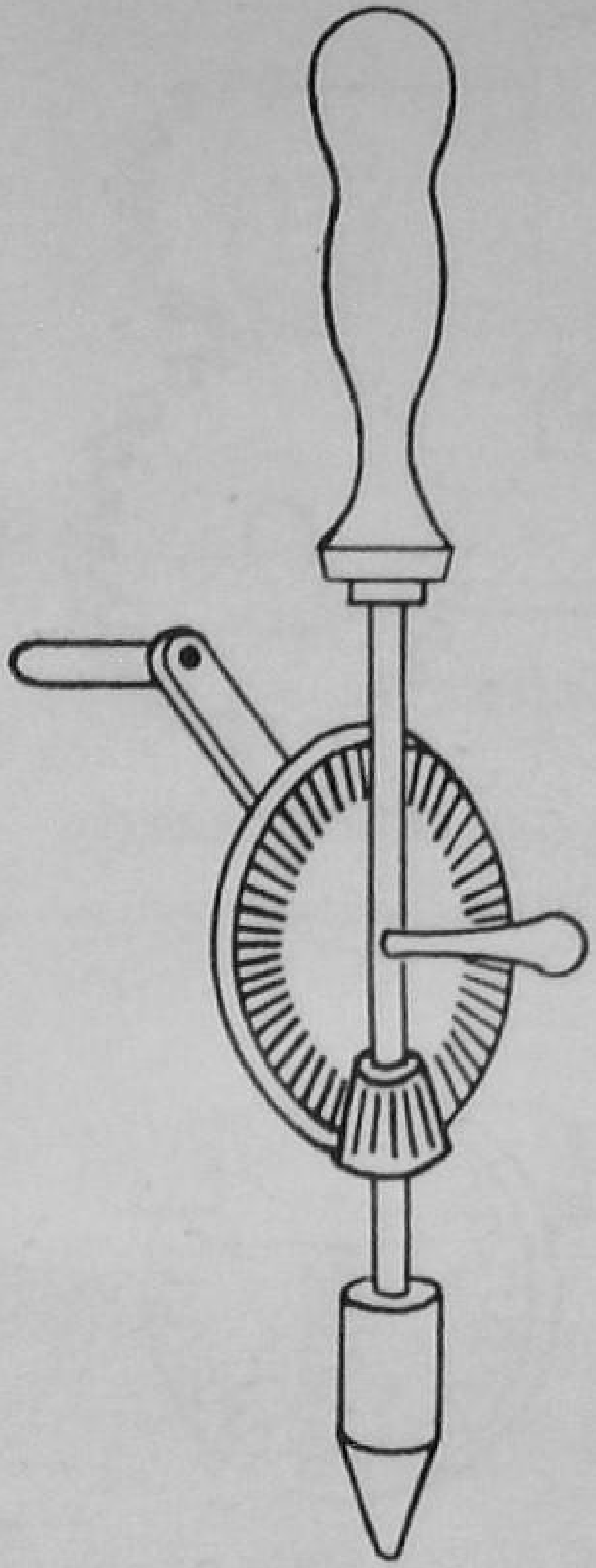


TAPS AND DIES

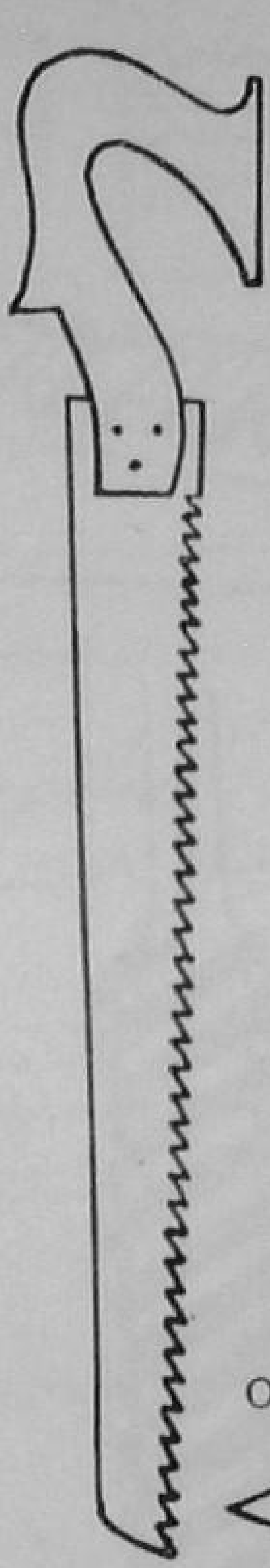


HAND DRILL

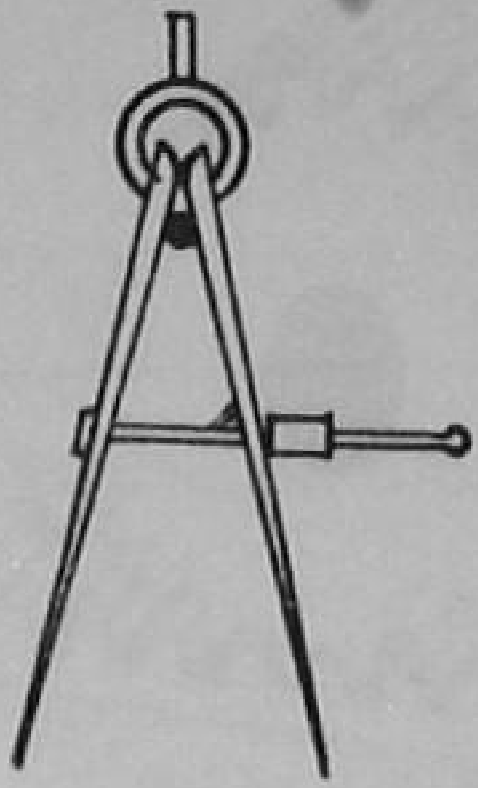
AG 106



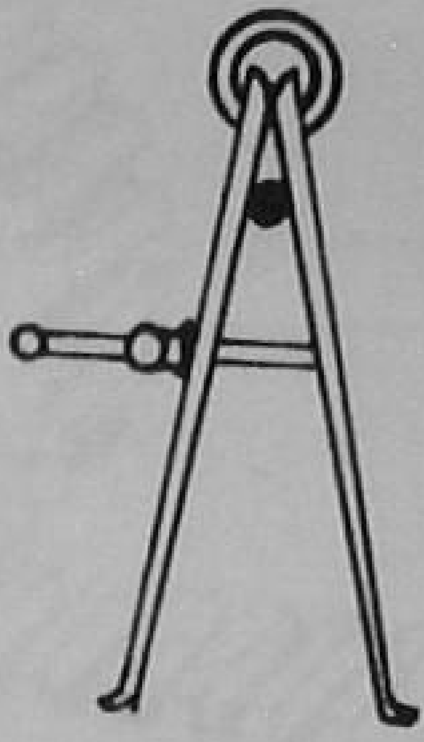
HAND DRILL



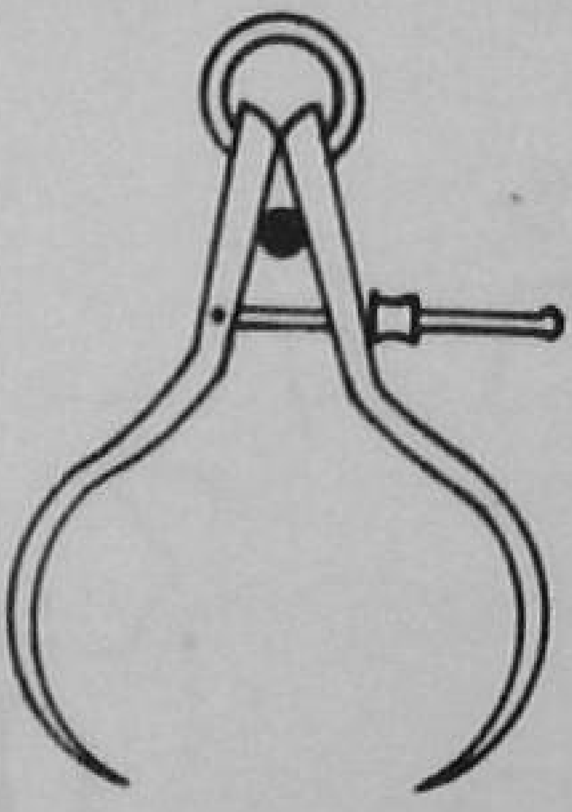
WOOD SAW



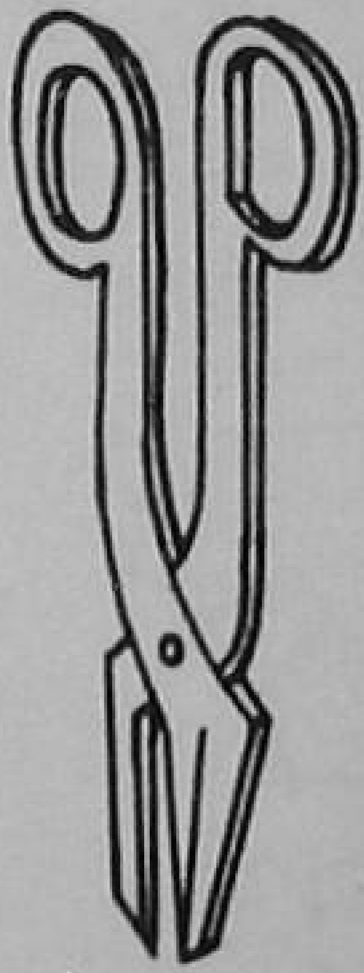
DIVIDER



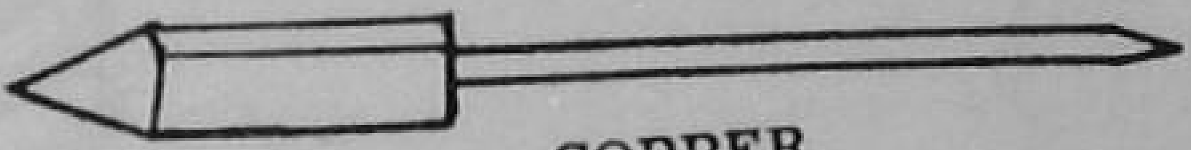
INNER CALLIPERS



OUTER CALLIPERS

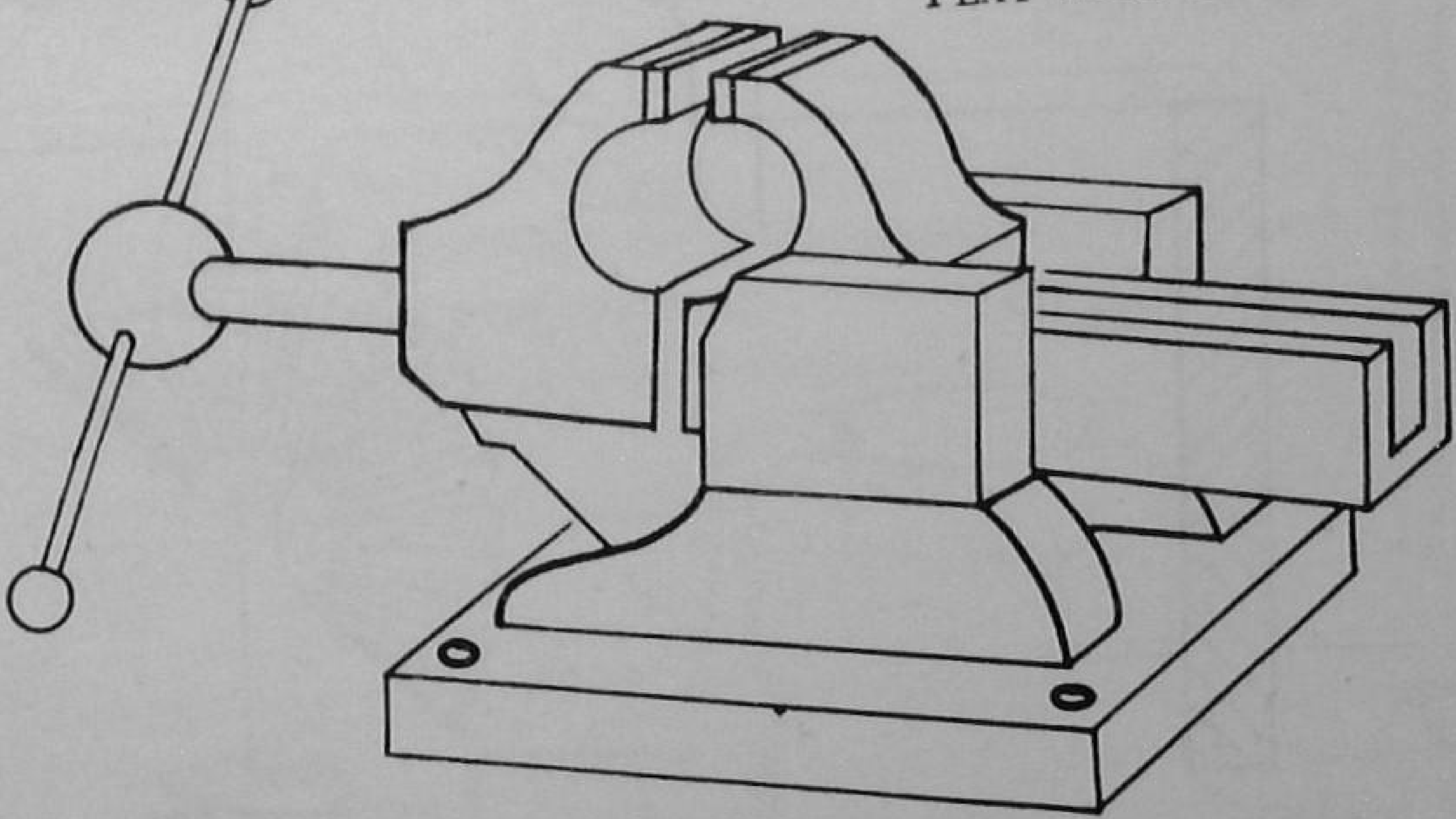


TINNER'S SNIPS

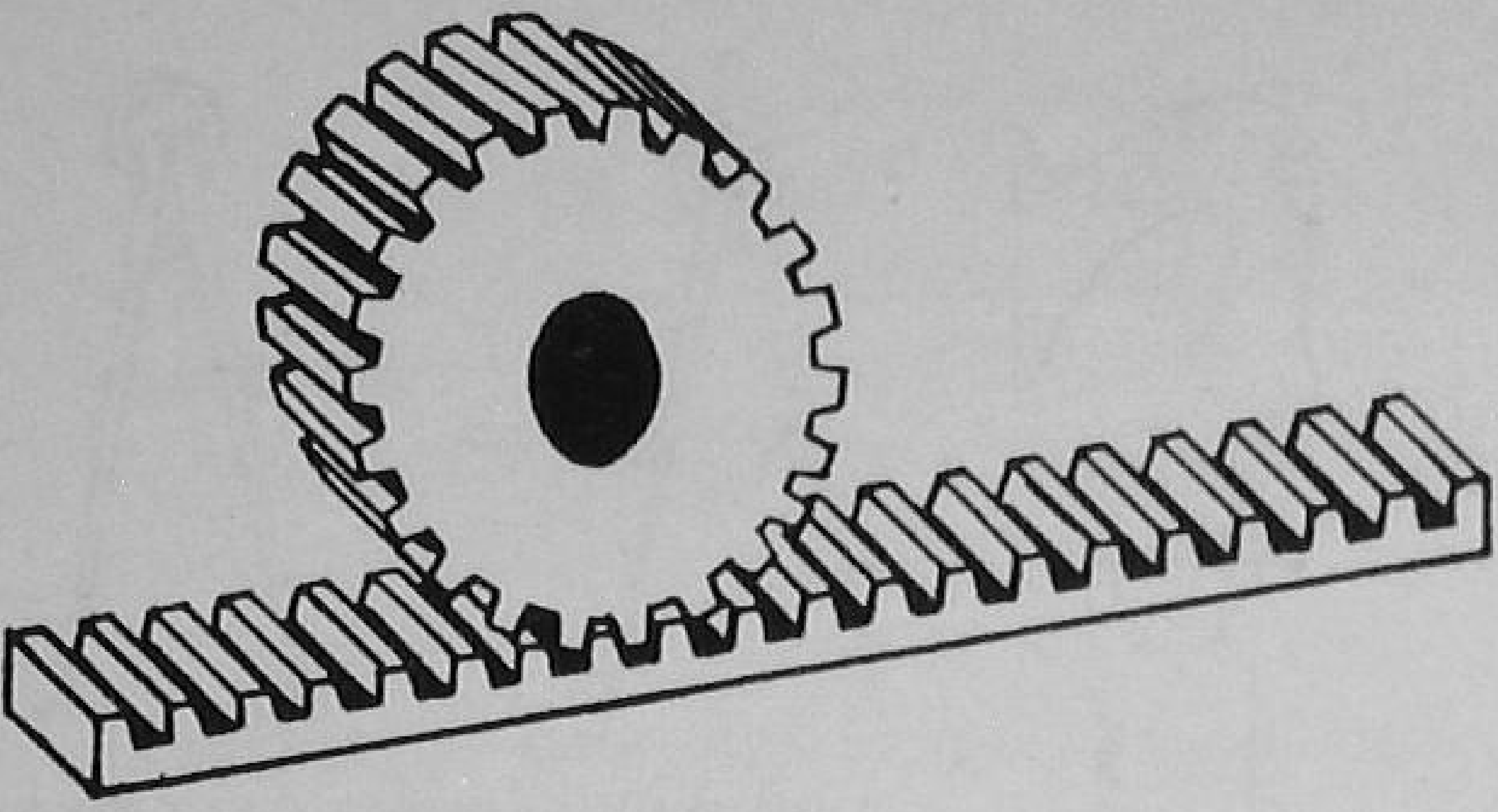


COPPER

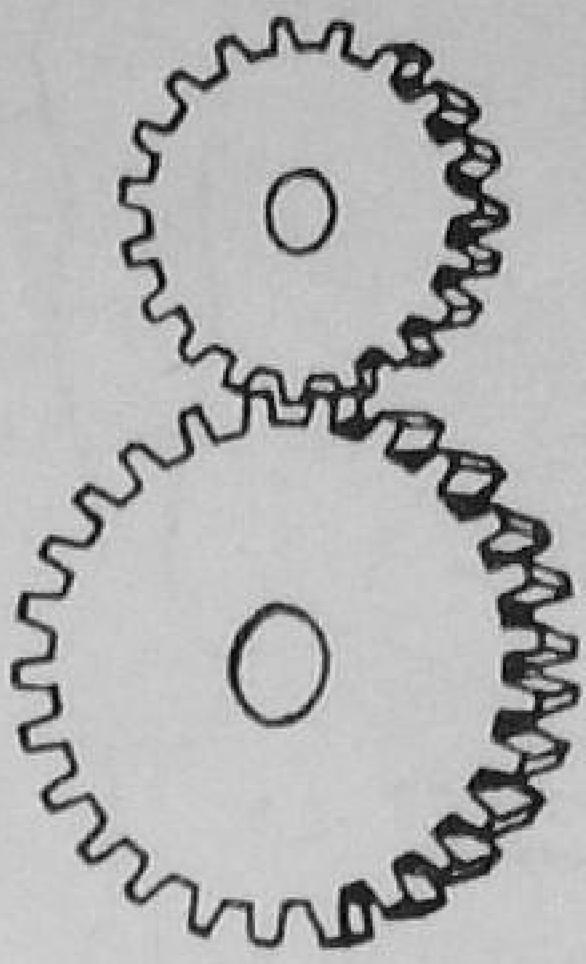
FLAT WOOD CHISEL



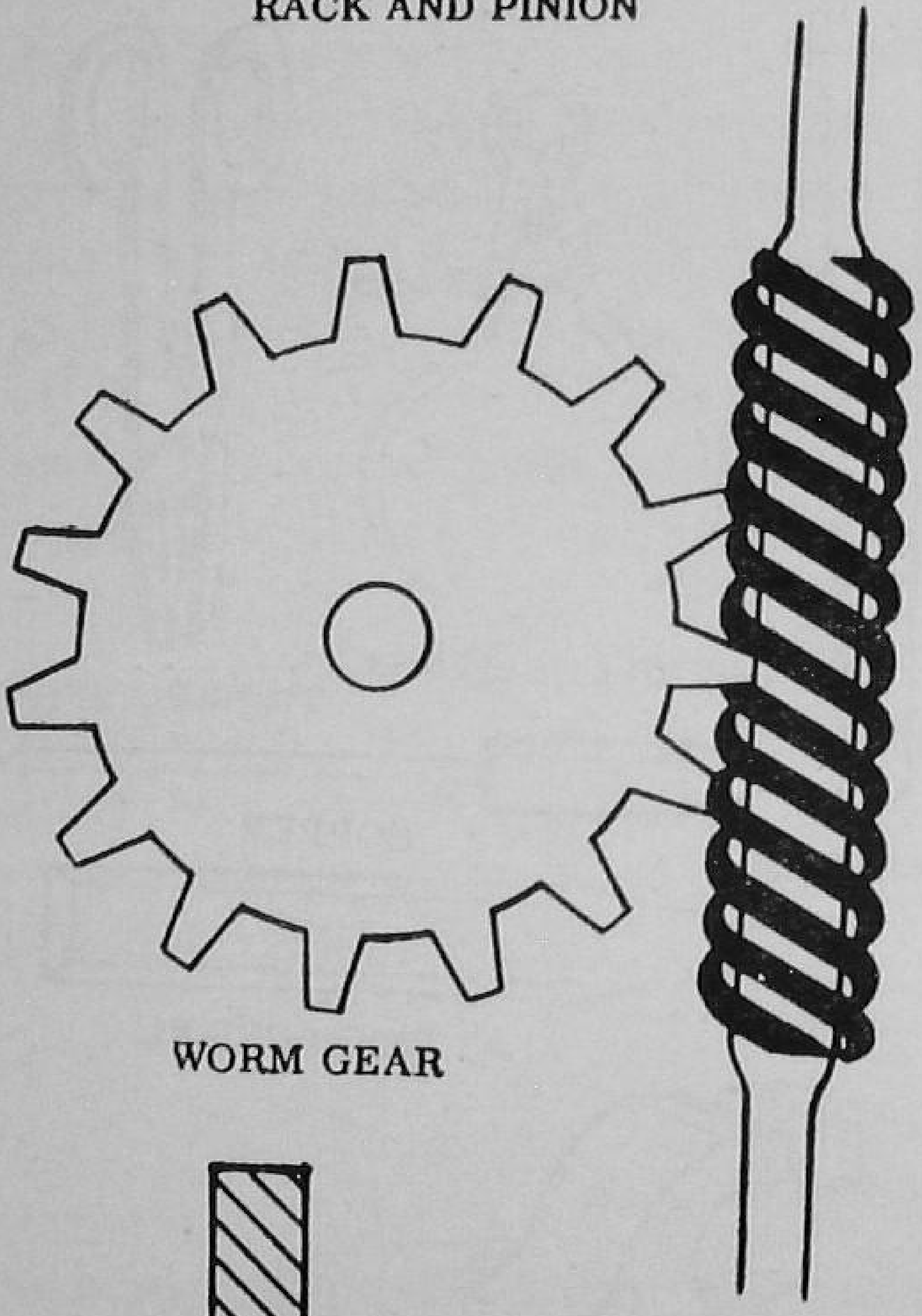
VICE



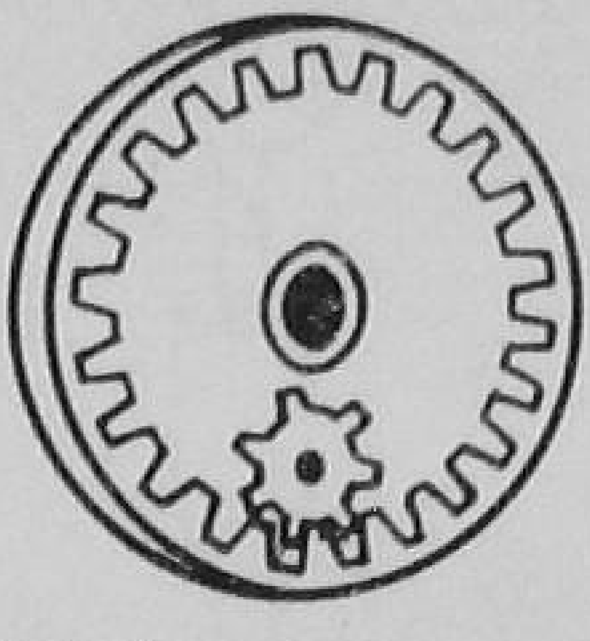
RACK AND PINION



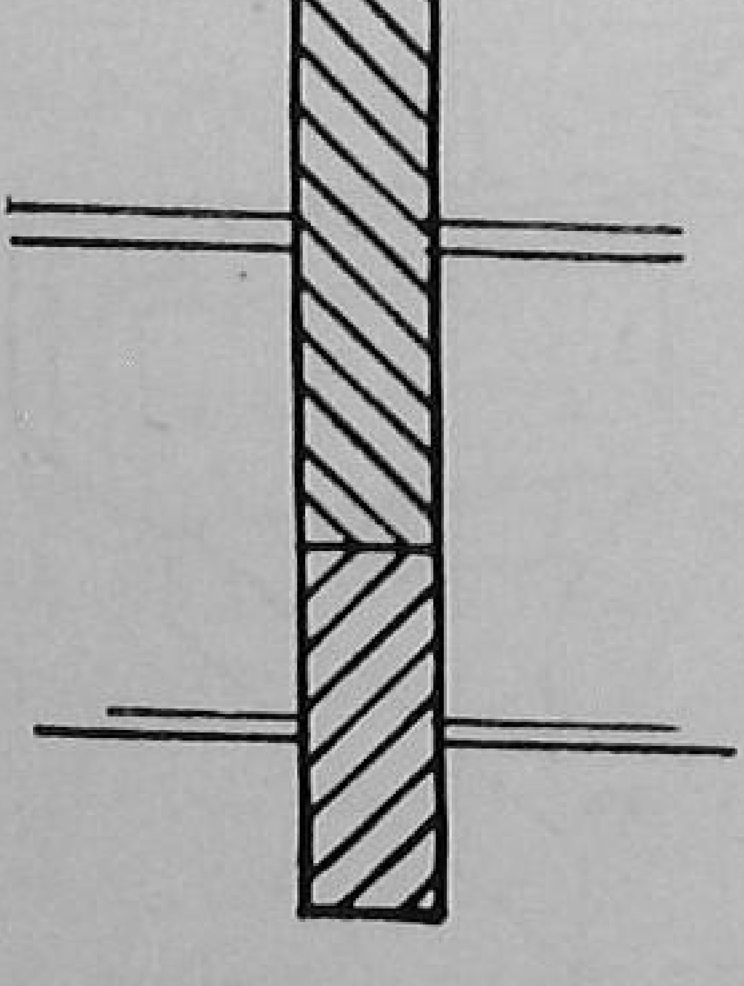
SPUR GEARS



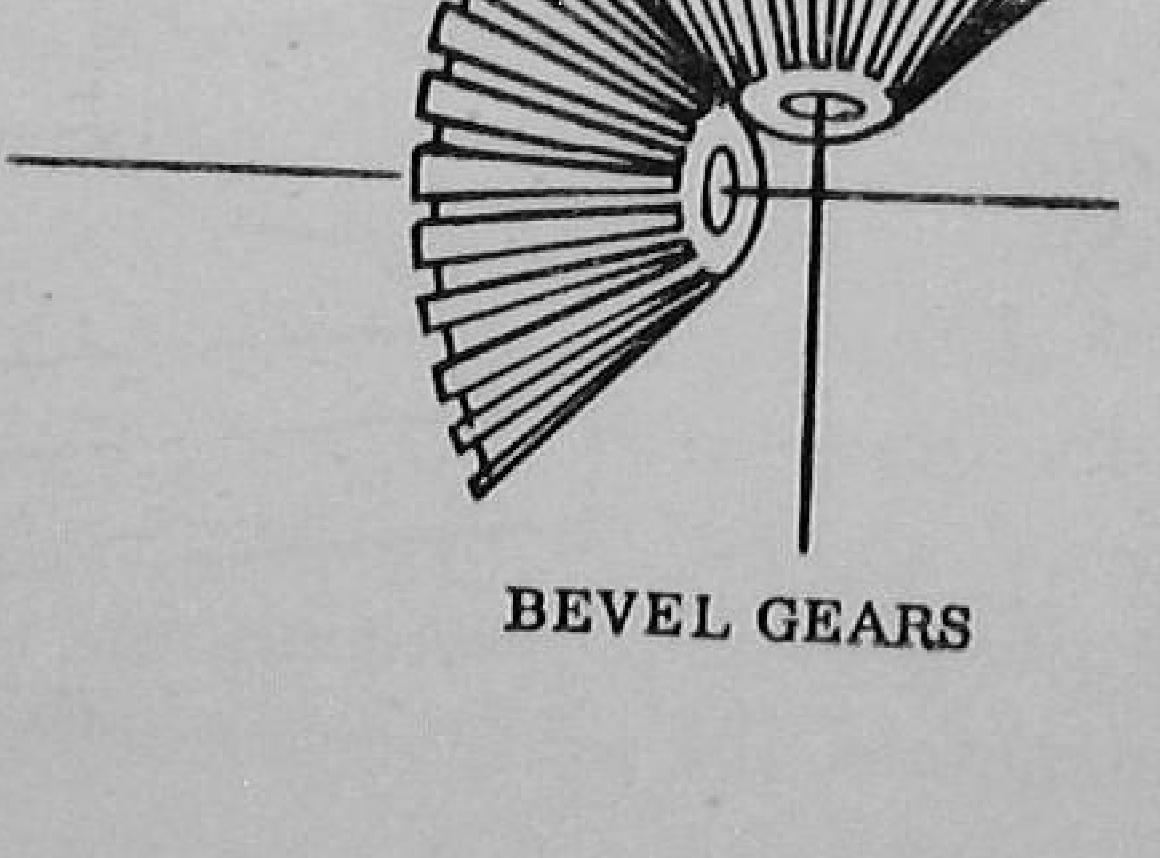
WORM GEAR



INTERNAL SPUR GEARS



HELICAL GEARS



BEVEL GEARS

Chapter 2

ELEMENTARY MECHANICS AND MATERIALS OF CONSTRUCTION

A student of agricultural engineering must have a general knowledge of the various machine parts used in the construction of agricultural machinery and also of the materials used in their fabrication. This knowledge will help him to understand the different mechanisms in a better way and to operate them efficiently. Such a study will also help the student to be resourceful and to understand new machines which he may come across in his work.

For the construction of any machine, two types of materials are used. They are:

(1) Raw materials

(2) Prepared materials

Raw materials comprise wood, mild steel, sheet metal, cast iron, brass, etc. Prepared materials comprise nuts, bolts, screws, chains, sprockets, leather belts, gears, bearings, clutches, levers, washers, springs, etc., which can be obtained ready-made from the market.

Raw Materials

Wood: In Western countries, iron has replaced wood in the construction of agricultural machinery, but in India, wood still holds its place because it is cheap, readily available and can be processed by village carpenters. For agricultural purposes, hard wood such as *babool* should be preferred. Mango, *sal*, *khira* and *neem* wood is also used according to availability. For the construction of boxes for fertilizer spreaders, seed-drills, etc., teak wood should be used. The wood should be dry and well cured or seasoned so that shrinkage does not spoil the construction later. In costly machines, the wooden parts should be well painted.

BAMBOO: Bamboo is commonly used for the construction of agricultural implements in those parts of the country where it is grown, such as Kerala, West Bengal and Assam. It is used in the construction of yokes, beams of agricultural implements, clod-crushers, handles and framework.

SHEET METAL: Mild steel sheets are used for constructing *gur* pans, soil scoops, sheet metal boxes, etc. Galvanized sheet metal is used for constructing winnowing fans, dusters, sprayers, windmills, grain storage bins, etc. Sheets of 22 to 24 gauge are considered ideal for normal use.

STEEL: Mild steel flats, rounds and structural steel such as angle irons, 'I' beams, channels, etc., are very commonly used in the construction of agricultural machinery. Where exceptional strength is required and where the part is subjected to a lot of friction, high carbon steel is used. Mild carbon steel contains about 0.15 to 0.25 per cent of carbon, whereas high carbon steel contains about 0.90 to 1.05 per cent of carbon. The hardness of steel is determined mainly by its carbon content.

Soft centre steel consists of two layers of hard steel between which a layer of soft steel is welded. This steel is used for preparing mould-boards of ploughs, because it is hard, strong and keeps good polish.

CAST IRON: Cast iron contains 2.2 to 4.3 per cent carbon. Cast iron pieces can be welded by using oxy-acetylene gas flame. They can also be joined together by heating and applying a brazing compound. Castings do not have much strength and cannot be hammered. Cast iron is mostly used for preparing bulky and irregular shapes, because it can be moulded.

BRASS AND BRONZE: Brass is a compound of copper and zinc, and bronze is a compound of copper and tin. These are used for preparing bush-bearings and other parts which need to be kept free from rusting.

BABBITT: Babbitt is a tin base alloy used in the bearings of oil engines.

Prepared Materials

A machine usually consists of various small parts such as

gears, bearings, pulleys, cams and chains which are readily available in the market.

Described below are some of the most important parts used in the construction of agricultural machines.

GEARS: Gears are wheels which have teeth. They are used for transmission of power and for increasing or decreasing revolutions.

Spur gears have teeth either on the inside or on the outside of their faces. In the case of spur gears, the shafts are parallel. *Bevel gears* have their shafts at right angles and are used for transmission of power in directions which are not parallel. *Helical gears* are like spur gears but their teeth are not straight. These gears are used where noise is to be eliminated. *Rack and pinion* is a good arrangement in which a small gear is used as a pinion and the rack is a long straight strip having teeth on it. A *worm gear* consists of a gear and a circular shaft with threads which mesh with the teeth of the gear. The shaft has got teeth cut around its periphery in such a way that when the gear revolves, the shaft revolves at a greater speed.

CLUTCHES: Clutches are used to engage or disengage gears or shafts as desired. There are two types of clutches namely *friction clutches* and *positive clutches.* Friction clutches consist of two discs pressed tightly together which turn as one unit whereas positive clutches have teeth. In case of machines where a high speed is required *safety clutches* are employed.

CAMS: Cams are used to produce intermittent motion.

ECCENTRIC WHEELS: Eccentric wheels are used in winnowers, manure spreaders, etc., for converting circular motion into to and fro motion.

RATCHET AND PAUL: The mechanism of Ratchet and Paul is used when motion in only one direction is required.

BEARINGS: The following types of bearings are generally used: *Bush-bearings, roller-bearings, hayatt roller-bearings, taper roller-bearings, single row* and *double row ball-bearings* and *end thrust-bearings.* Bush-bearings may be either solid or split. They consist of a piece of wood or cast iron with a hole bored through for the shaft. Ball-bearings and roller-bearings are

used where shafts are required to run at a great speed. Bearings are placed in bearing-blocks.

Universal Joints: Universal joints are used when power is to be transmitted at different angles. They are used in the bullock-gears meant for driving fodder cutters.

Chains: Chains may be of malleable iron or pressed steel. The chain links can be easily detached in order to shorten or lengthen the chain. Chains are used where positive transmission is required.

Pulleys: Pulleys may be prepared out of steel or wood, and are used for transmitting power with the help of either flat or V-shaped belts. The two ends of the flat belts are joined together by belt laces of alligator or clipper type. 'V' belts are used where slippage is to be eliminated. The belts may be made of leather or rubber. Ply belts, rubber and canvas belts are also used. Belts are very useful for transmission of power at a distance which is normally six times the diameter of the pulley.

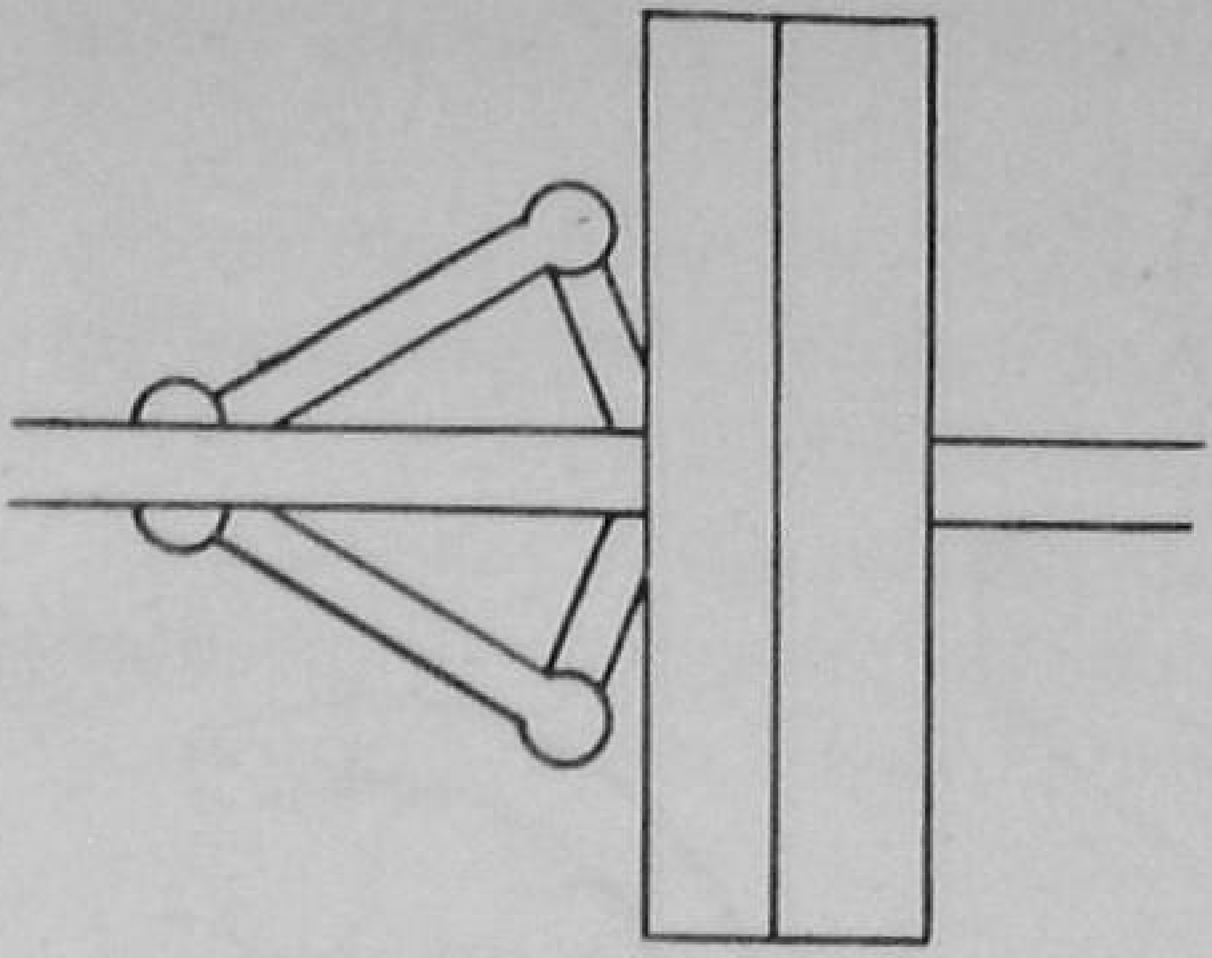
Keys: Keys are used for fixing pulleys, fly-wheels, etc., on the shafts. They fit into a slot in the shaft and the pulley, and turn them as one unit. Cotter or split keys are used when a hole can be drilled through the pulley and the axle.

Bolts and Nuts: There are many types of bolts used for fastening various parts of agricultural machinery. *Machine bolts* are used for fastening two metal parts together and they may have square or hexagonal heads. *Carriage bolts* have a round head with a square shoulder extending to about 1/2". *Plough bolts* have countersunk type heads which fit flush with surface. These are used in fastening plough shares and mouldboards to the frog. *Stove bolts* have threads running down close to the head. These are used for fastening thin metal pieces together.

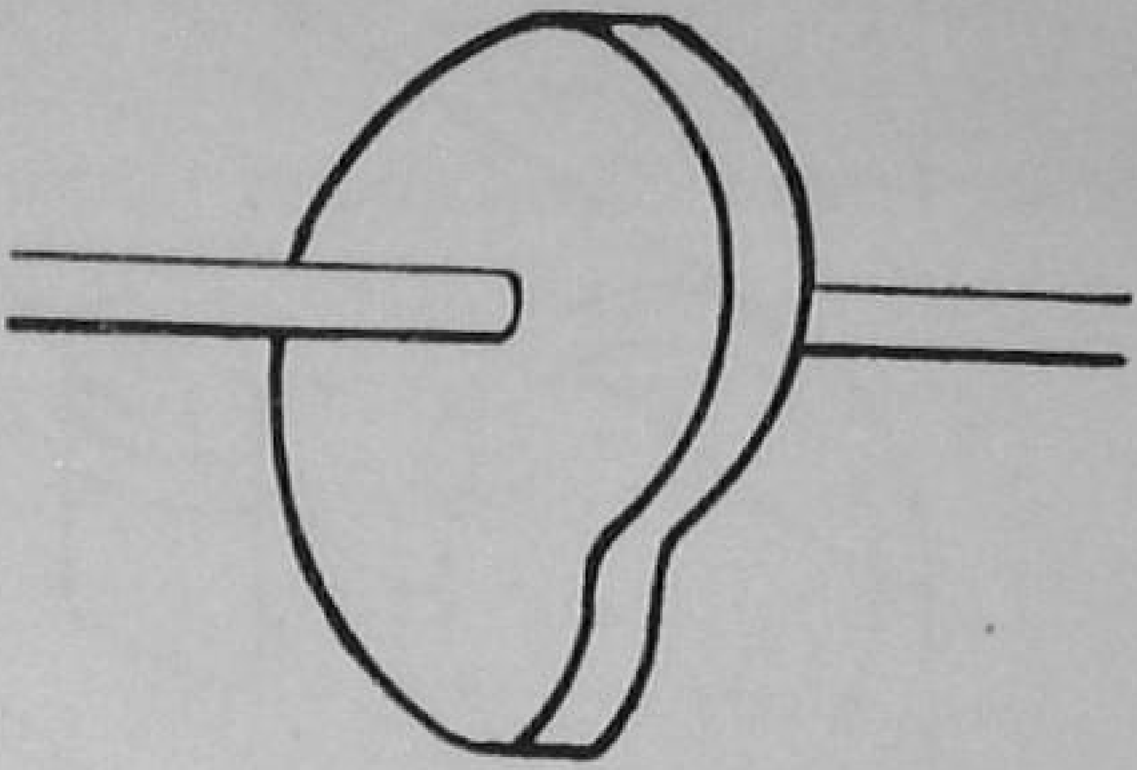
Nuts may be of square, hexagonal, wing or castellated type. Castellated nuts are used in oil-engines, and wing nuts are used where they are to be loosened by hand.

Screws: *Set screws* are used for preventing the moving parts from getting out of place.

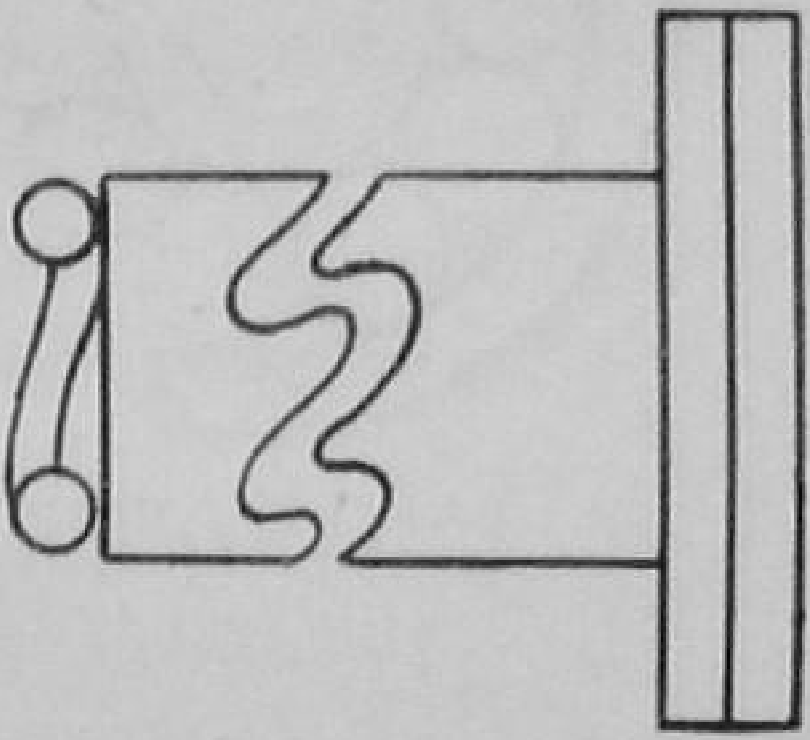
Studs or *cap screws* are used without nuts, because they



CLUTCH



CAM



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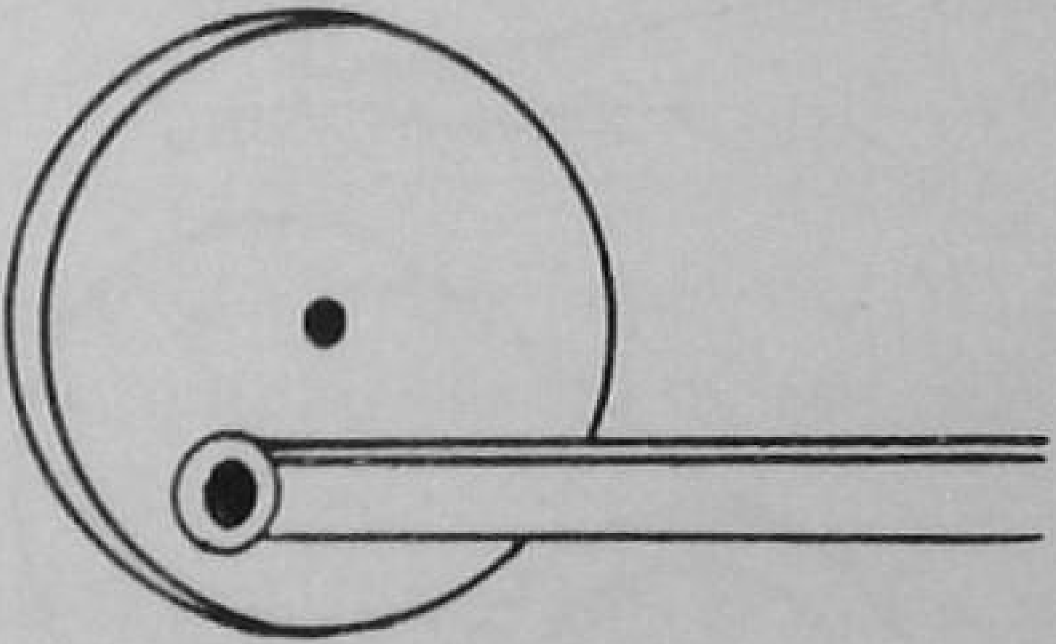

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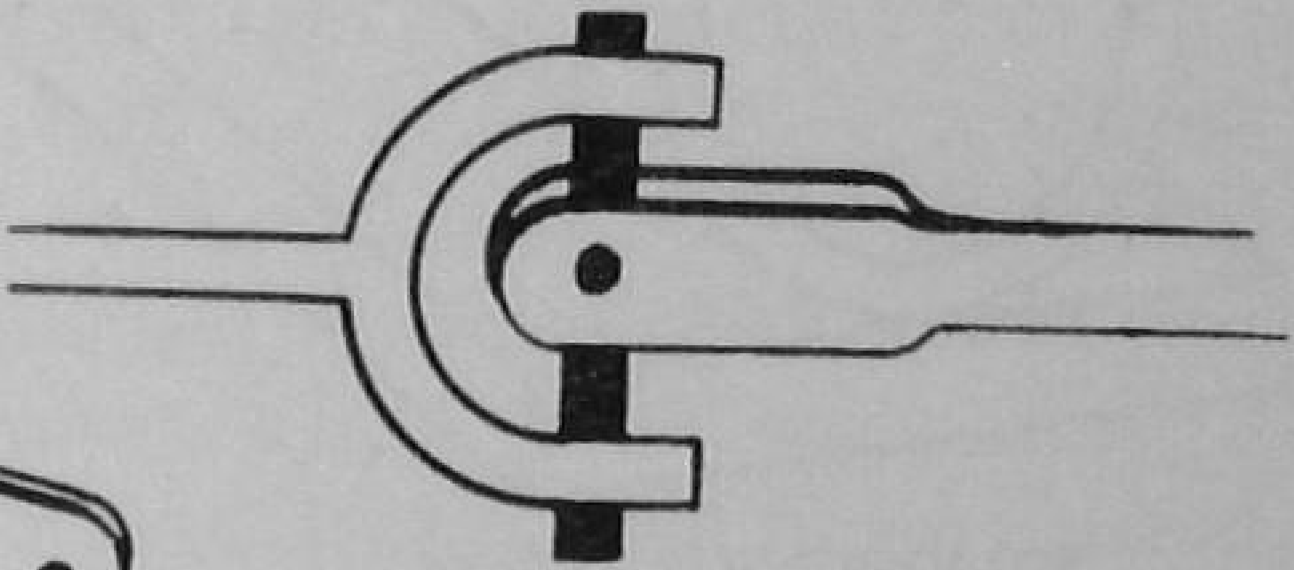

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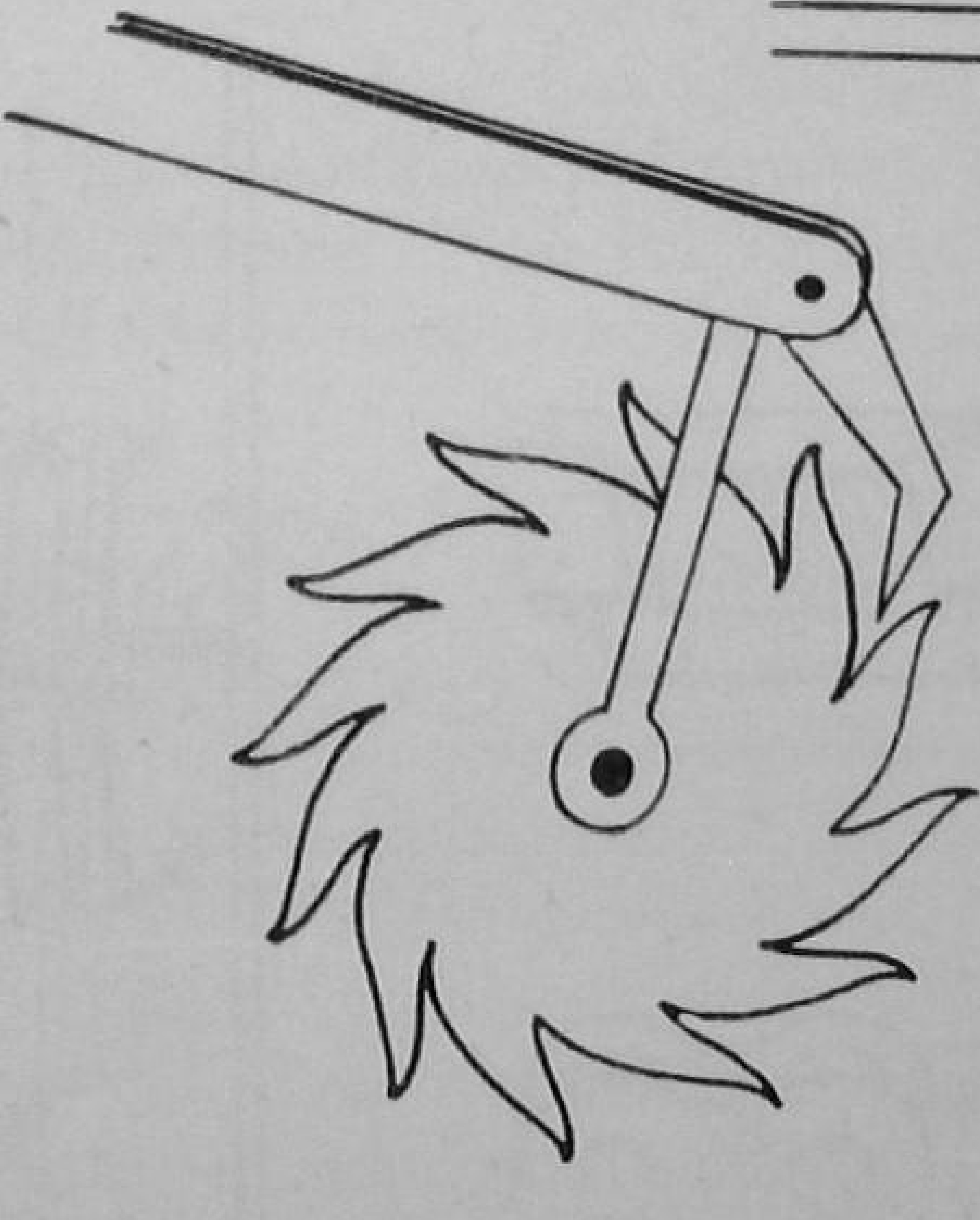

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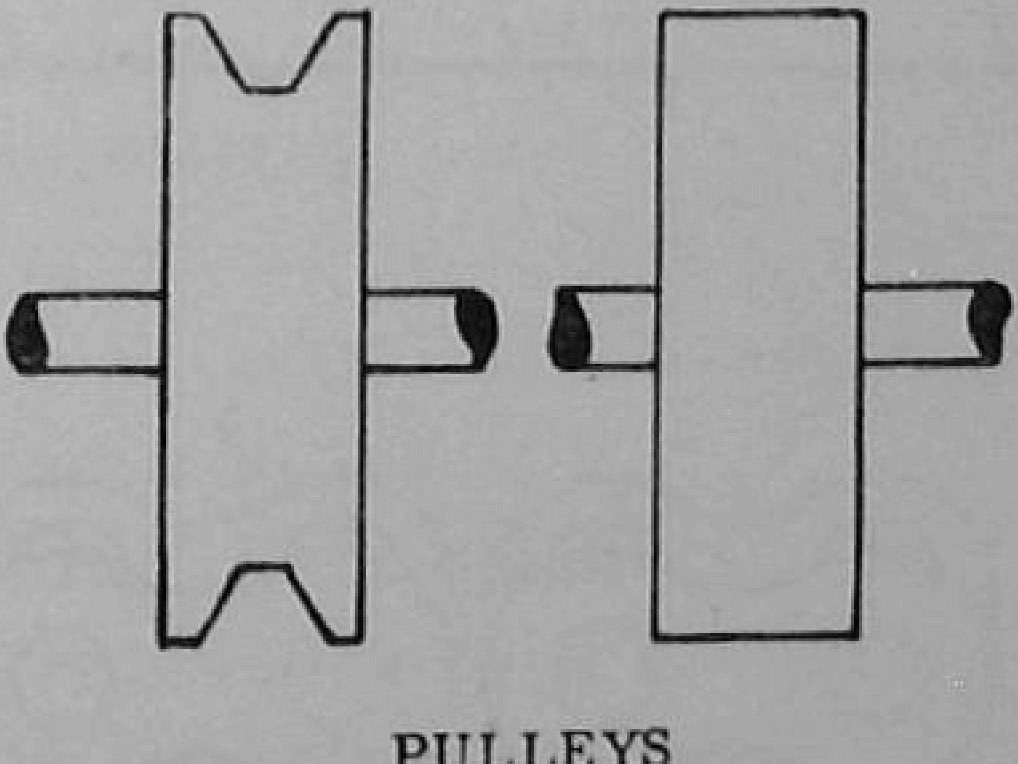

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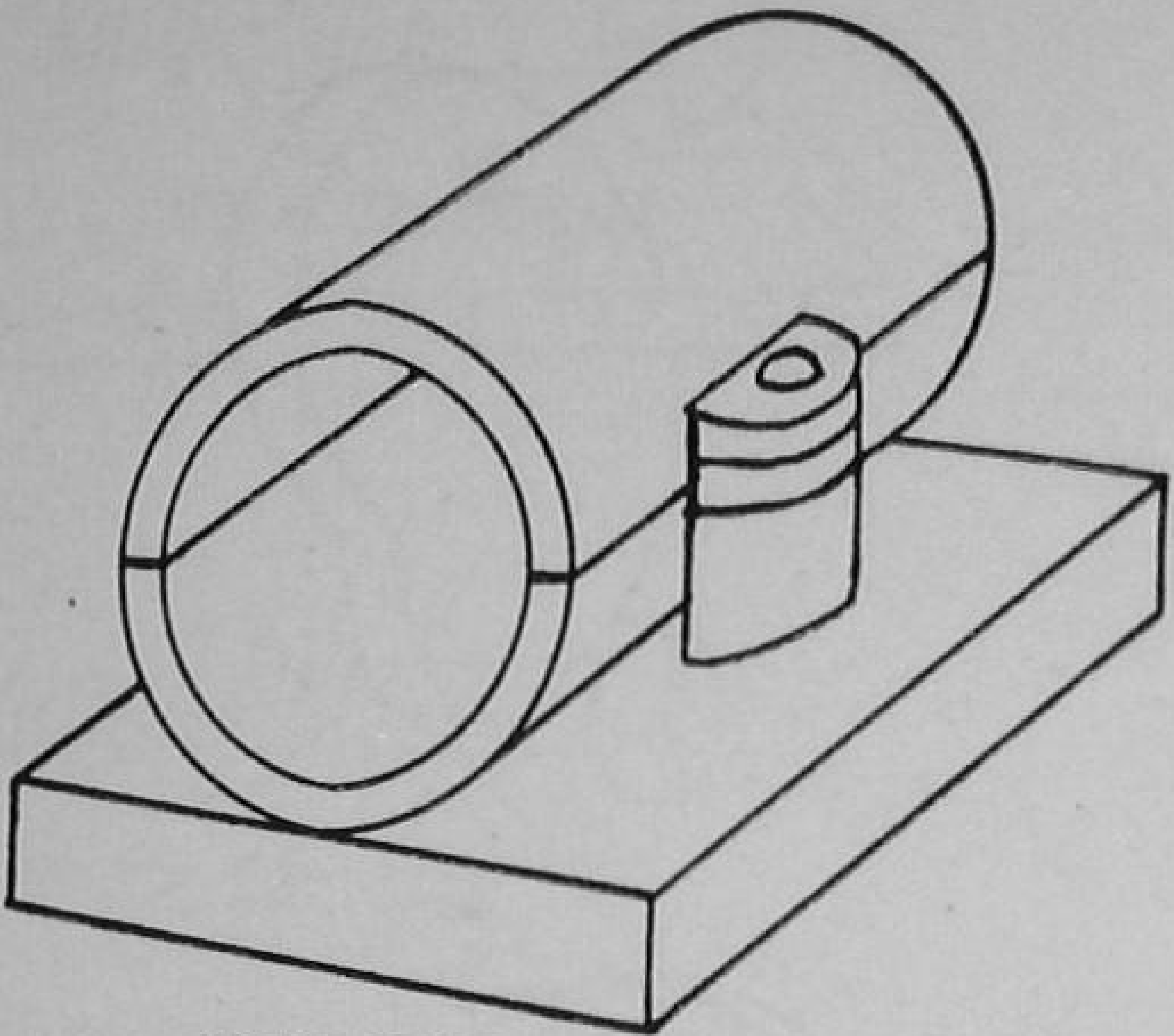

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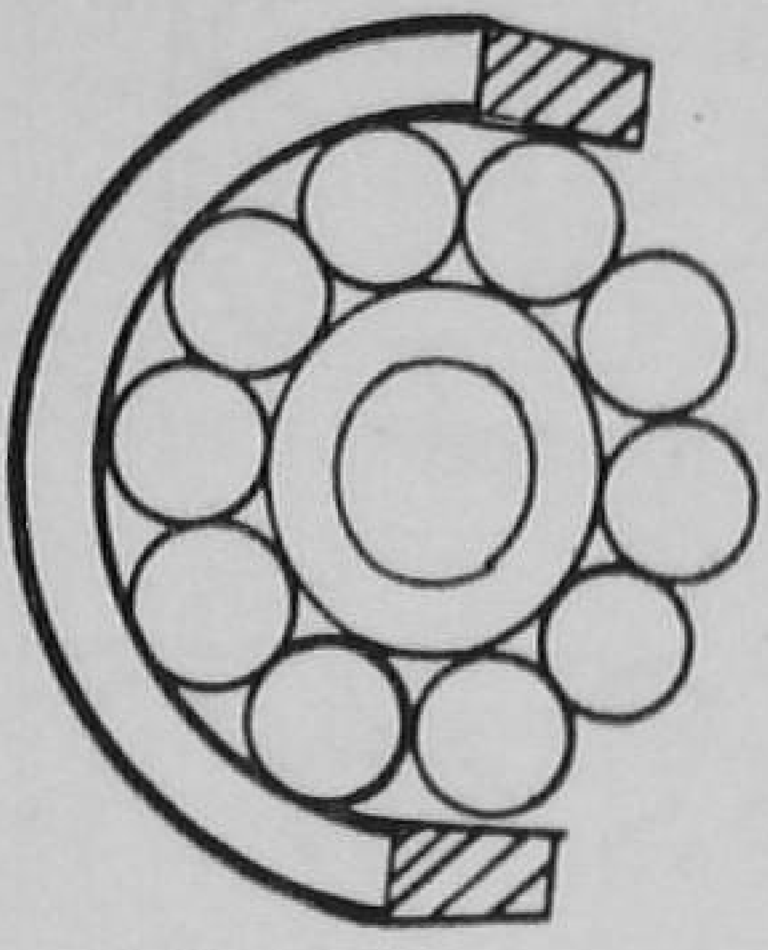
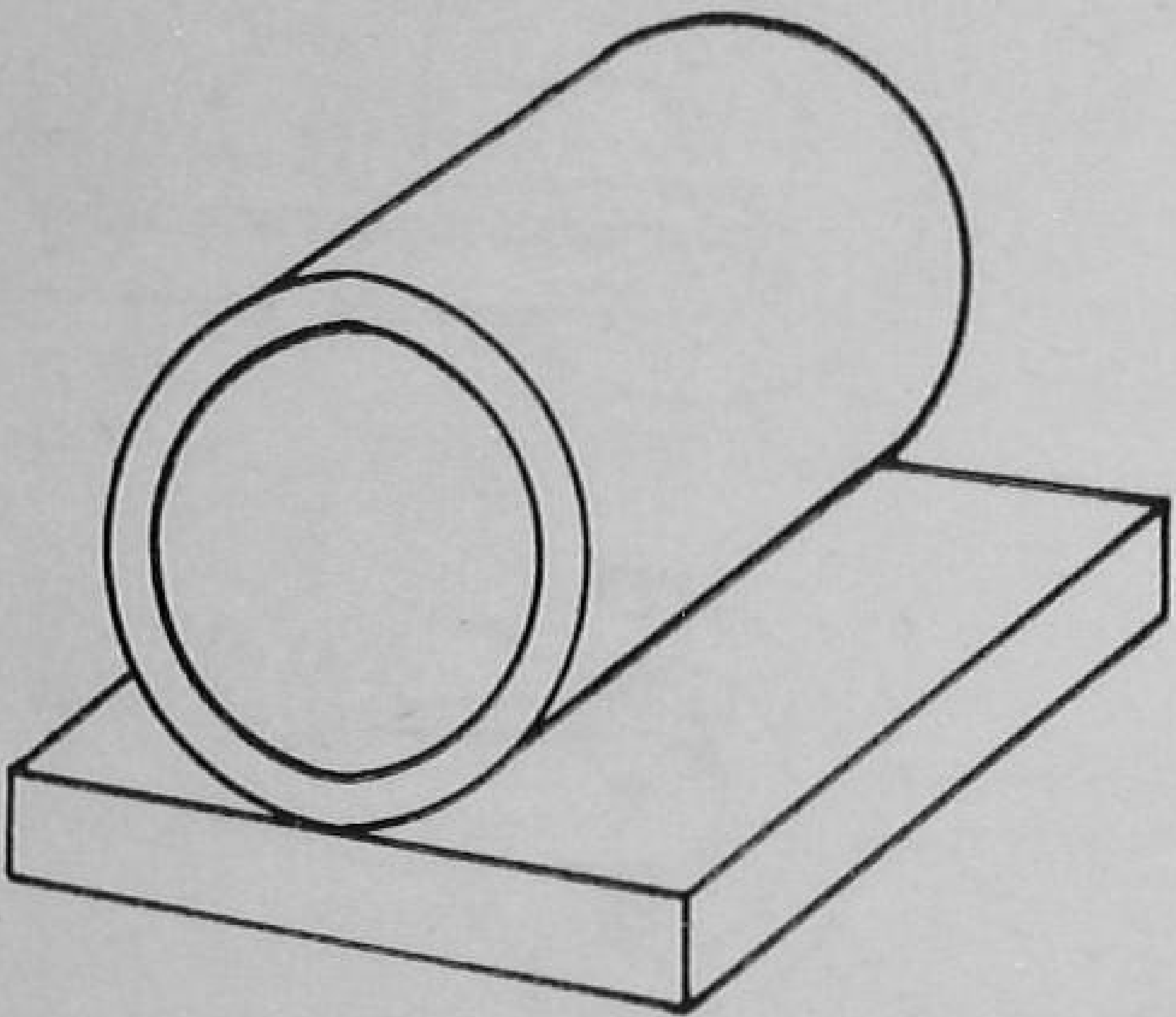
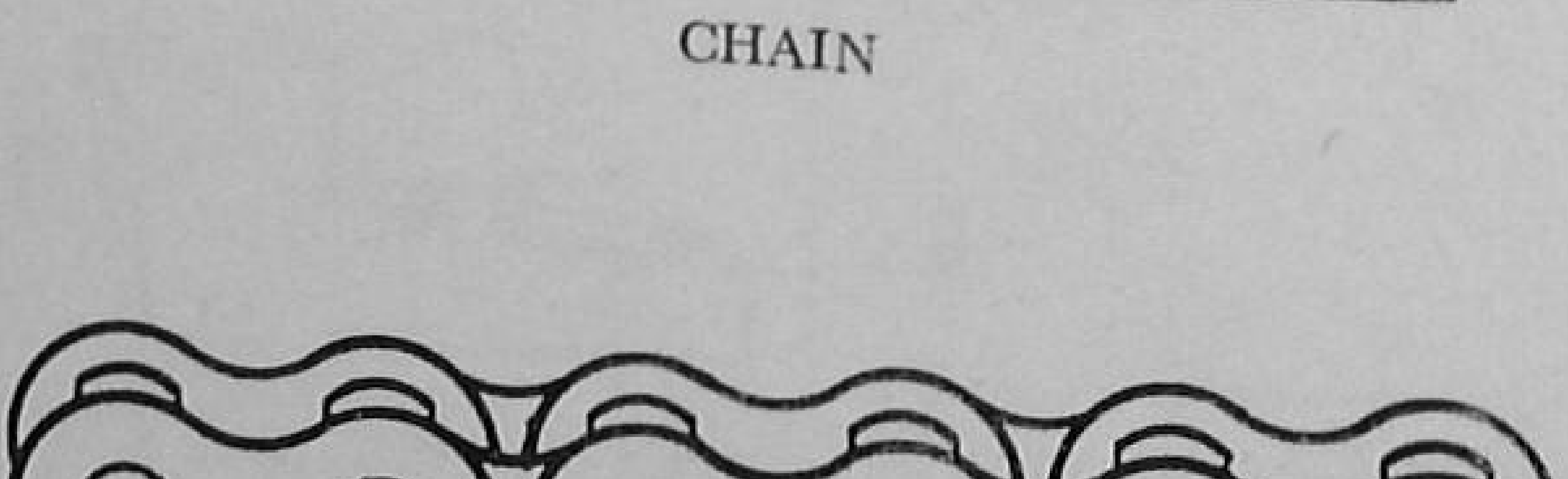


BALL-BEARING

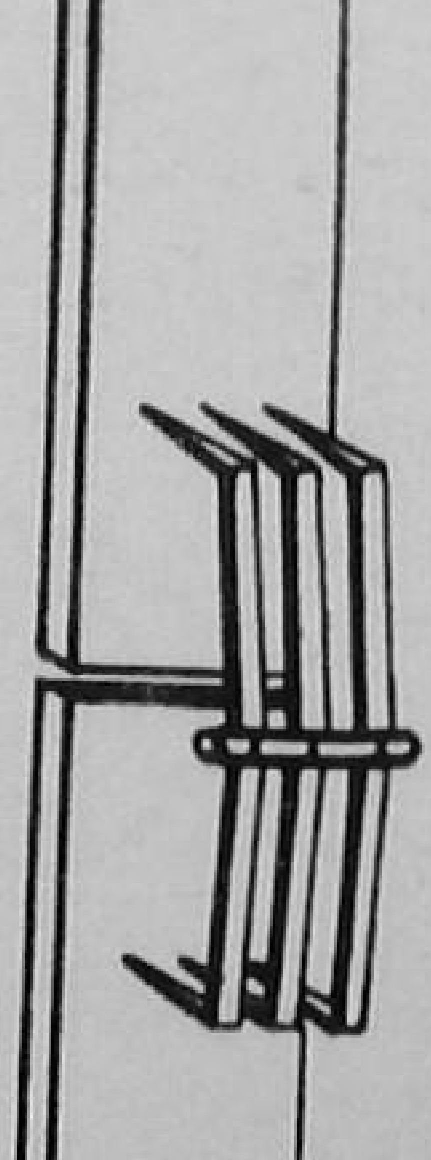


SOLID BUSH-BEARING

CHAIN



ROLLER CHAIN



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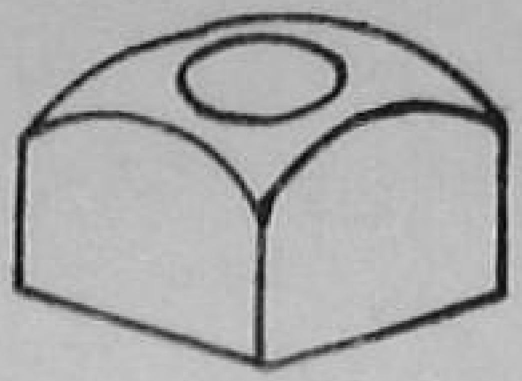
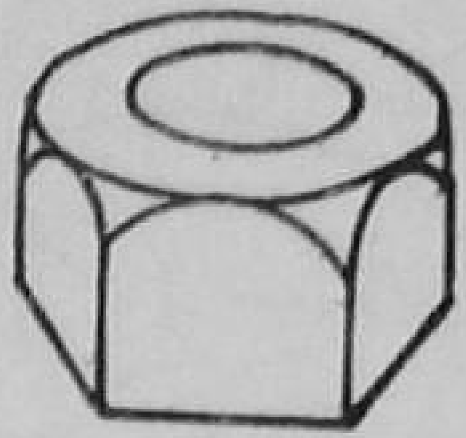
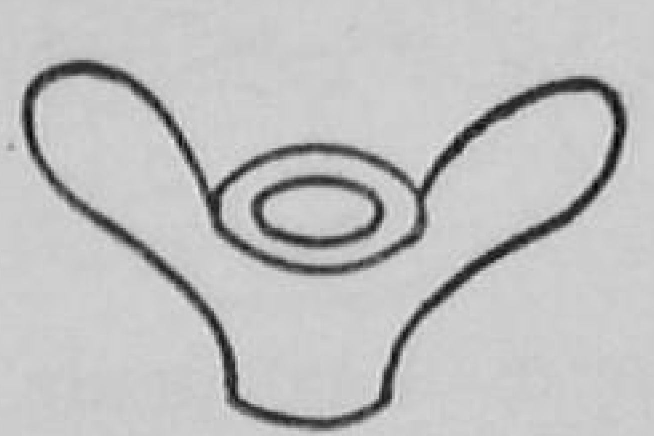


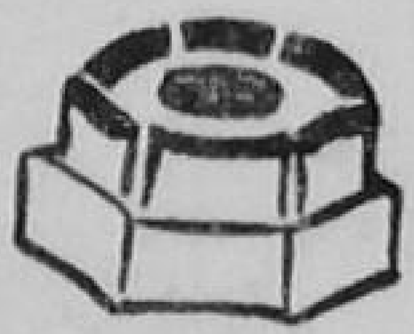
SQUARE NUT



HEXAGONAL NUT



WING NUT



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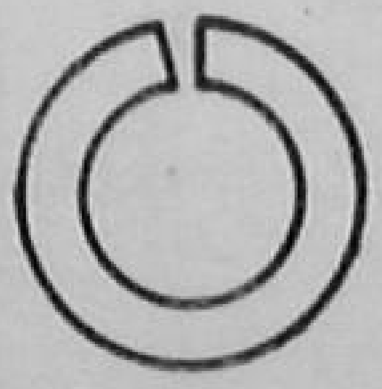
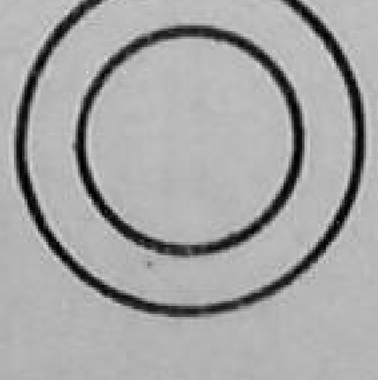


SPLIT WASHER



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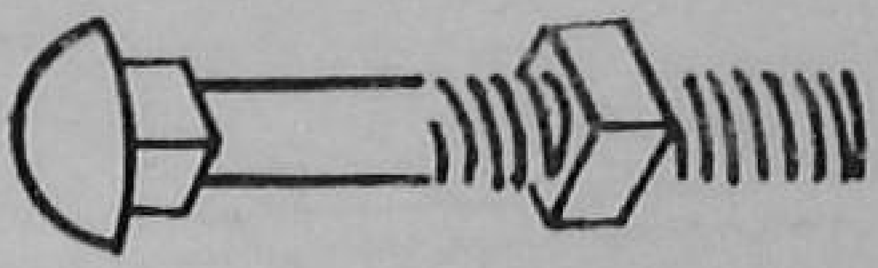
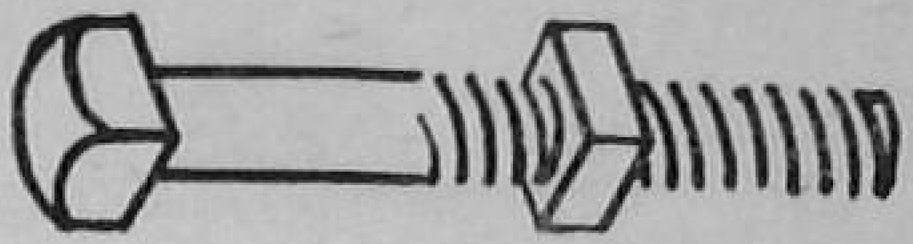
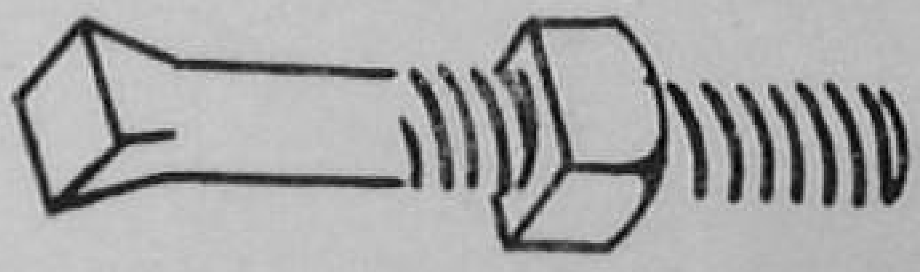


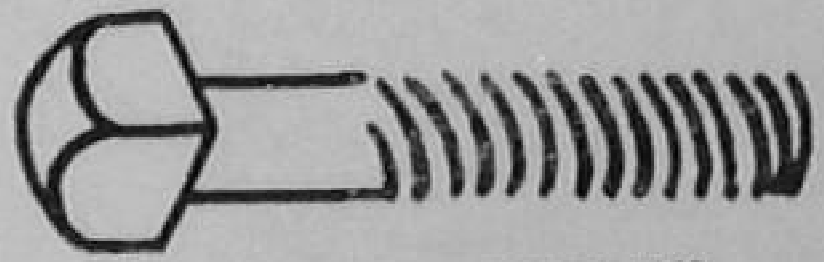
CARRIAGE BOLT



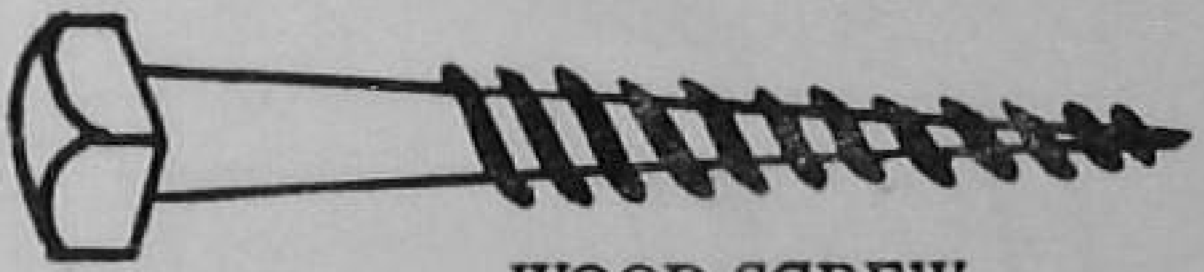
MACHINE BOLT



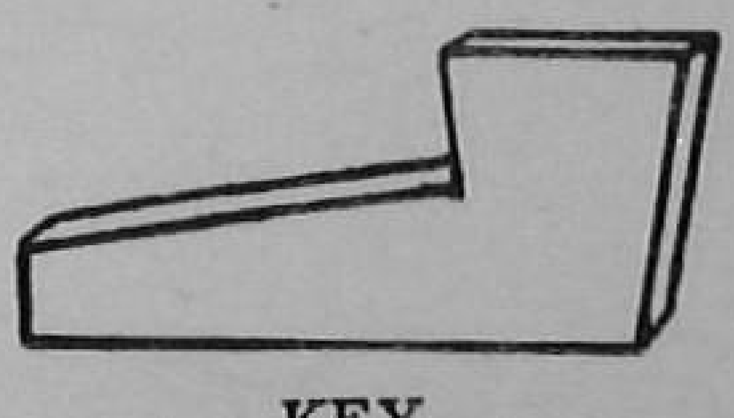
PLOUGH BOLT



WOOD SCREW



WOOD SCREW



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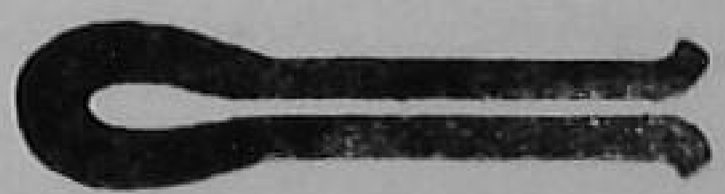
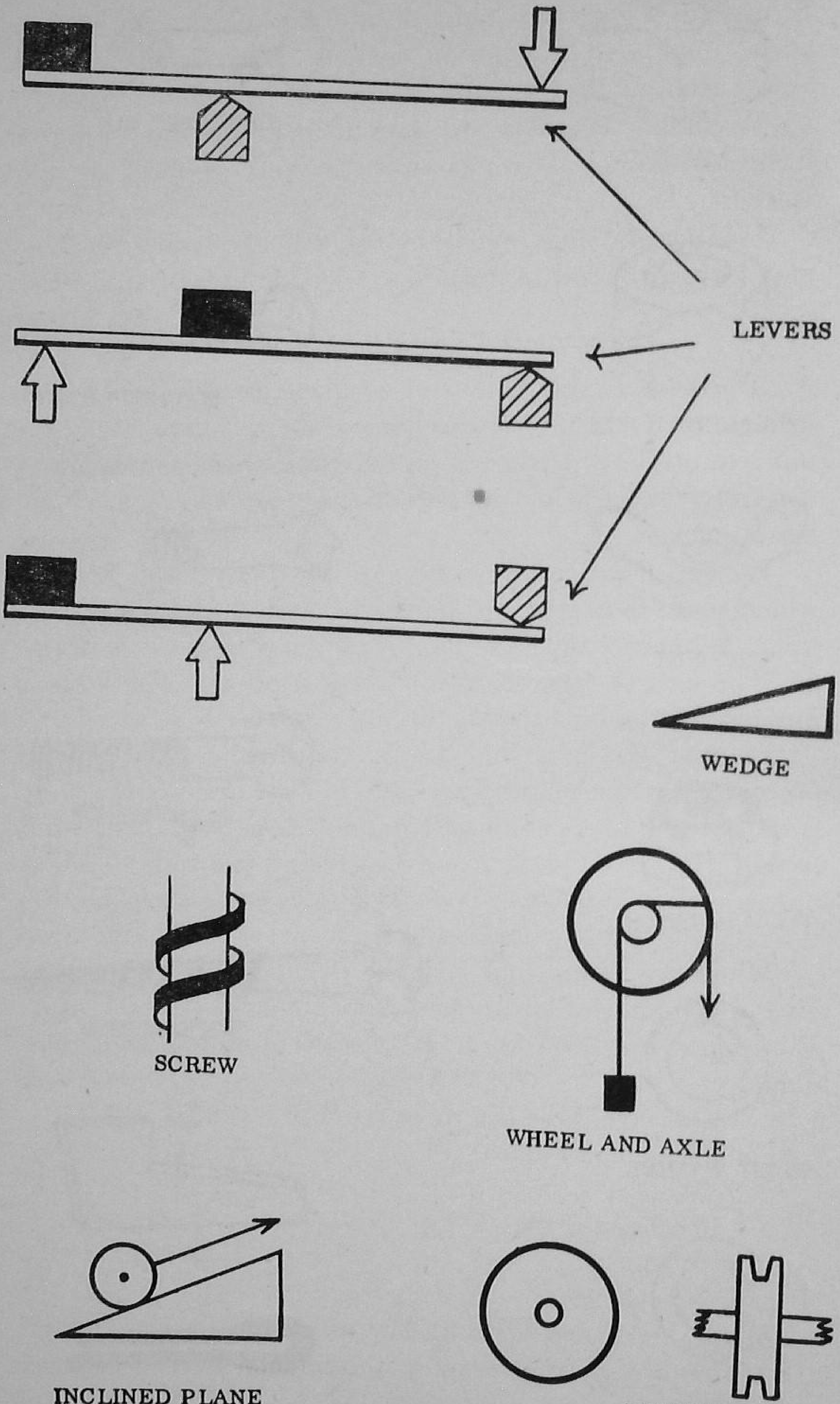


SPLIT PIN


LEVERS
WEDGE
SCREW
WHEEL AND AXLE
INCLINED PLANE
PULLEY

fit in with the threads made inside the holes in the castings such as cylinder heads of oil engines. *Lag screws* and *wood screws* are used for fastening machinery to wooden parts.

WASHERS: Washers are used to prevent nuts or screws from loosening. Washers may be lock washers or split washers.

SPRINGS: Springs may be of leaf, helical or coil type. They may be compressed or tortion springs or extension springs.

Elementary Principles of Mechanics

A Village Level Worker or a village artisan should learn elementary principles of mechanics. He will then be able to understand the construction and operation of farm machinery correctly. Given below are definitions of some basic mechanical terms.

FORCE: Force is the action of one body upon another which tends to produce or destroy motion in the body acted upon. Whenever such a motion is produced, work is performed. The unit of measuring work is foot-pound. The force is measured in pounds and the distance in feet.

POWER: Power is the rate of doing work. The unit of power used is foot-pounds per second or per minute. If a body is moved one foot per minute against a force of one pound weight, the rate of work is one foot-pound per minute. If it moves so that 33,000 foot-pounds work is done each minute, the rate is called one horse power.

MACHINE: A machine may be defined as a device that gives a mechanical advantage. A machine used in the ordinary sense may consist of a number of simple machines namely:

1. Lever (There are three types of levers)
2. Wheel and axle
3. Pulley
4. Inclined plane
5. Wedge
6. Screw

MECHANICAL ADVANTAGE: The mechanical advantage of a machine is the ratio between the force delivered by the

machine and the force applied. The efficiency of a machine is the ratio between the work accomplished by it and the work applied to the machine. Because of the frictional losses, the efficiency of every machine is always below 100 per cent.

CHAPTER 3

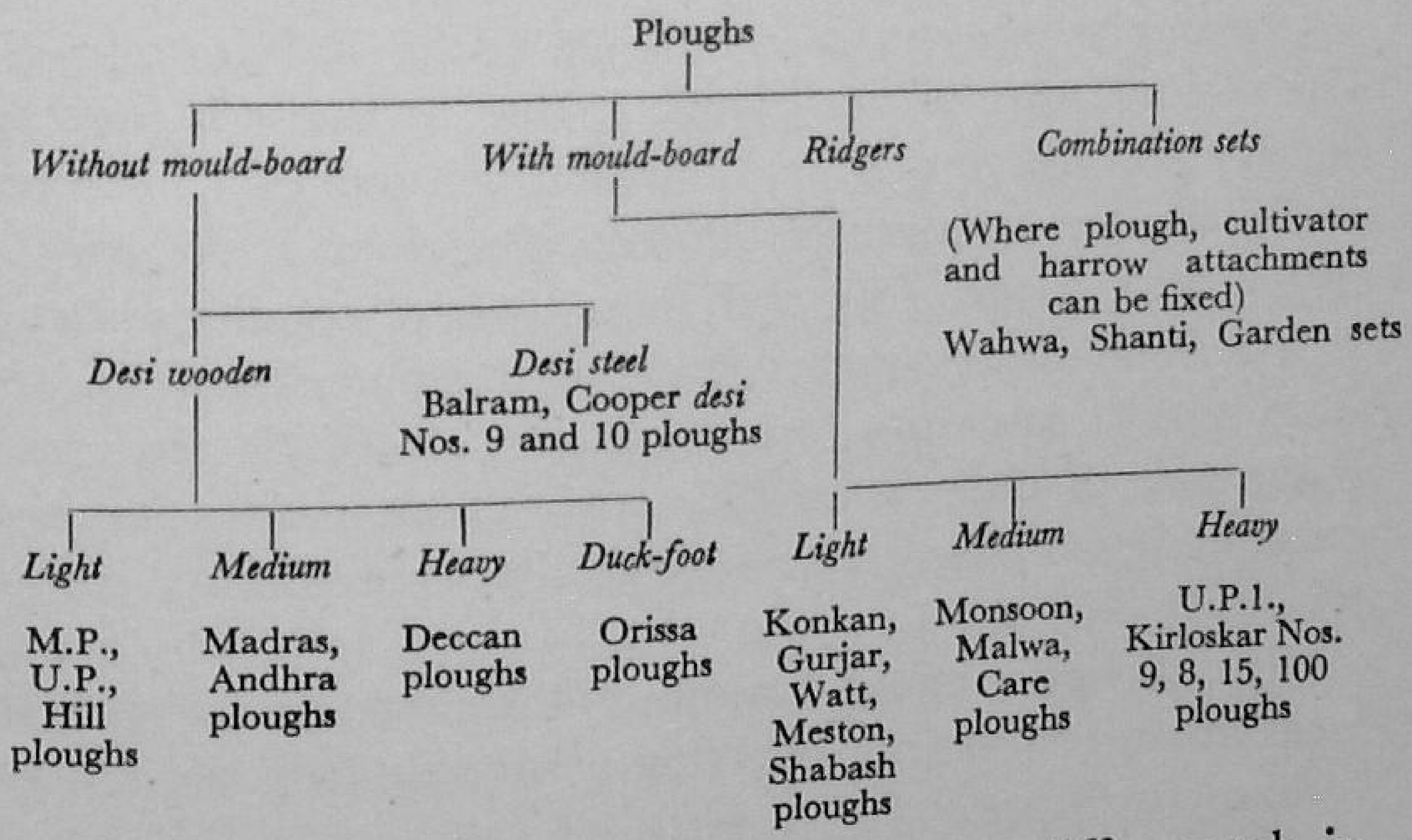
PLOUGHS

Ploughing is the most important primary operation in agriculture. Hence, implements used for ploughing are considered very important. Ploughing essentially means opening the upper crust of the soil, breaking clods and making the soil suitable for sowing seeds. If big clods are encountered, operations such as cultivating, harrowing and levelling are done after ploughing.

Probably, ploughing was the first operation performed by the ancient man with the help of a bent stick, when he took to agriculture. Ploughs are mentioned in the *Mahabharata*. The plough was the emblem of Balram, the brother of Lord Krishna.

Millions of *desi* ploughs are being used today by Indian farmers. In some parts, however, mould-board ploughs have become popular because of their superior design, durability and the quality of work performed by them.

Ploughs may be classified in broad groups as follows.



The design of the *desi* plough does not differ much in the different parts of the country. In some parts, the ploughs

are big and in others small. Only in Orissa, the design differs materially, and a *desi* plough of the duck-foot type is used. It is claimed that this type of plough is better for puddling rice fields.

The *desi* plough consists of an L-shaped piece of wood, and is manufactured either by using a single L-shaped piece or by joining two pieces. It has a steel share, a pulling beam and a small handle. The depth of the plough is adjusted by means of wedges fixed in the plough body and also by adjusting the position of the yoke at the end of the pulling beam. When the yoke is taken forward the plough goes deep, and when the yoke is taken backward towards the body of the plough, the plough goes shallow.

In northern India, the *desi* plough is usually small and can be lifted by a man. Here the plough is a multipurpose implement and is used for sowing seed also.

In the black cotton soils of the Deccan, heavy ploughs which require two to three pairs of bullocks are used. These ploughs, which have bar shares, are manufactured by village carpenters out of well-seasoned *babool* wood. The cost ranges from Rs. 5 to 10 per plough. For fixing the bar, various methods are employed, the best amongst them being a ring which is used in the Deccan plough.

An improved type of *desi* plough is the Balram plough. The main feature of this plough is that its shape is just like the *desi* plough, but it is manufactured out of iron, thus combining the strength of the iron plough with the simplicity of the *desi* one. The body is cast out of tough cast iron. A detachable share is provided so that it can be changed when worn out. It can work to a depth of 6″ to 8″. It requires a single pair of bullocks in light and medium soils and two pairs in heavy black cotton soils. Its approximate cost is Rs. 40 to 45.

This plough is a good example of the efforts being made by local manufacturers for evolving a suitable iron plough for Indian conditions.

The Indian plough is not a soil inverting plough but may be termed as a sort of cultivator in the Western sense.

The aim of ploughing is to pulverize the soil, break clods, uproot and kill weeds, conserve moisture, invert the soil, increase drainage, encourage the activities of beneficial bacteria and mix manure.

Though ploughing is a very common operation, it does not necessarily mean that it is as easy as is generally supposed. In modern times, hundreds of ploughs have been designed to suit various soils, crops and sizes of bullocks. A thorough knowledge of the construction of ploughs is necessary in order to make a proper selection and to work them efficiently.

Mould-board Ploughs

The design of a modern mould-board plough is based on exact mathematical formulae which are quite complicated. Ploughing is, therefore, both a science and an art. In the following paragraphs are described the main parts of a typical mould-board plough and their functions.

Parts of the Mould-board Plough

BODY: It is the base to which the handle, the beam, the share and the mould-board are fixed. The place where the share is fixed to the body is known as frog. The lower portion of the body which moves flush with ground, if the plough is well adjusted, is called landslide.

HANDLE: The handle is usually fixed to the body at an angle of 45°. A hook is provided on the handle to tie the bullock rope to it. Once the plough has been properly adjusted, the bullocks do not require much guidance.

BEAM: The beam should be strong and should have enough clearance so that clods and trash may pass freely under it. The clearance should be equal to the depth of ploughing. It is observed that beam clearance reduces the draught of the plough. For most of the heavy ploughs short beams are preferred.

CLEVIS OR BRIDLE: Horizontal and vertical clevises are located on the end of the beam, and are provided for adjusting the depth and width of ploughing. They are very

important. The plough is fixed to the yoke by means of a chain or a rope which connects the clevis and the yoke.

WHEEL: The wheel of a plough assists in balancing the plough and does not allow it to go deep. It should not be used for adjusting the depth.

SHARE: The share is the part which cuts the soil. It should, therefore, be sharp, well polished and pointed. The cutting edge should be thoroughly chilled. Countersunk bolts should be used for fixing the share to the frog to reduce friction.

The bend of the share is termed as suction. Its bend downwards in relation to the landslide is termed as vertical suction, and its bend on a side in relation to the landslide termed as horizontal suction. The vertical suction should be about $\frac{1}{4}''$ to $\frac{3}{4}''$ and the horizontal suction $1/8''$ to $1/2''$, according to the size of the plough. Suction helps in the penetration of the plough.

MOULD-BOARD: The mould-board should have a proper shape to turn over the soil and bury the uprooted weeds. It should have a good finish and polish so that soil friction and draught are reduced. Both the share and the mould-board should be manufactured under expert supervision to maintain the quality and likeness so that replacement is easy. Cast iron shares and mould-boards should not be used on the ploughs. They break easily, cannot maintain sharp edges and increase friction, and prove to be costly in the long run. Soft centre steel should preferably be used for mould-boards.

In addition to these parts there are other minor parts such as nuts, bolts, hooks, rings, straps and 'Y' part.

The following are the advantages of the mould-board plough over the *desi* plough.

1. It ploughs deep and pulverizes the soil well.
2. It inverts the soil.
3. It is more durable.
4. If well made and adjusted properly, it requires little guidance.
5. It requires less pull.
6. Heavier mould-board ploughs can work even in very hard soils.

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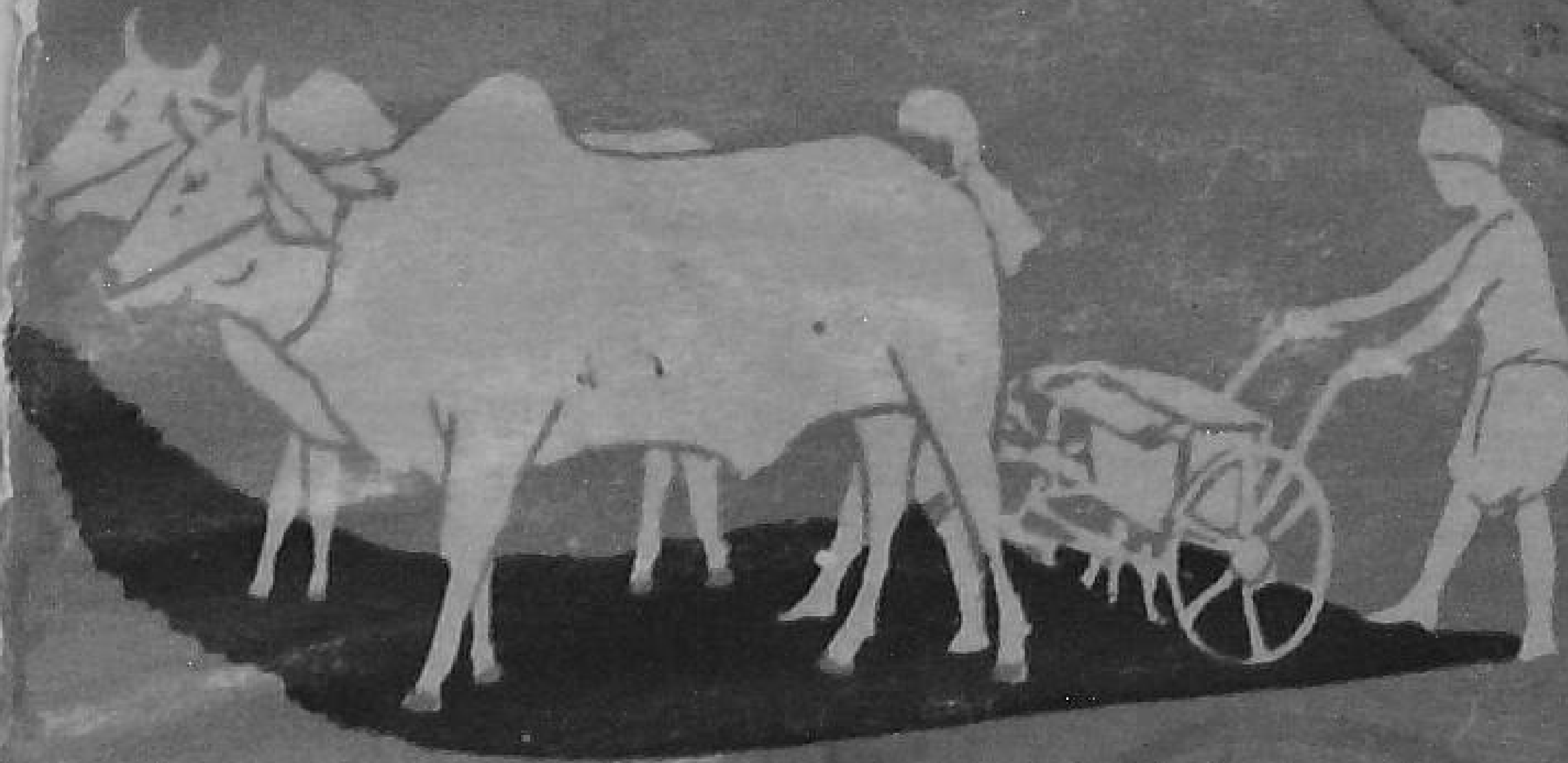

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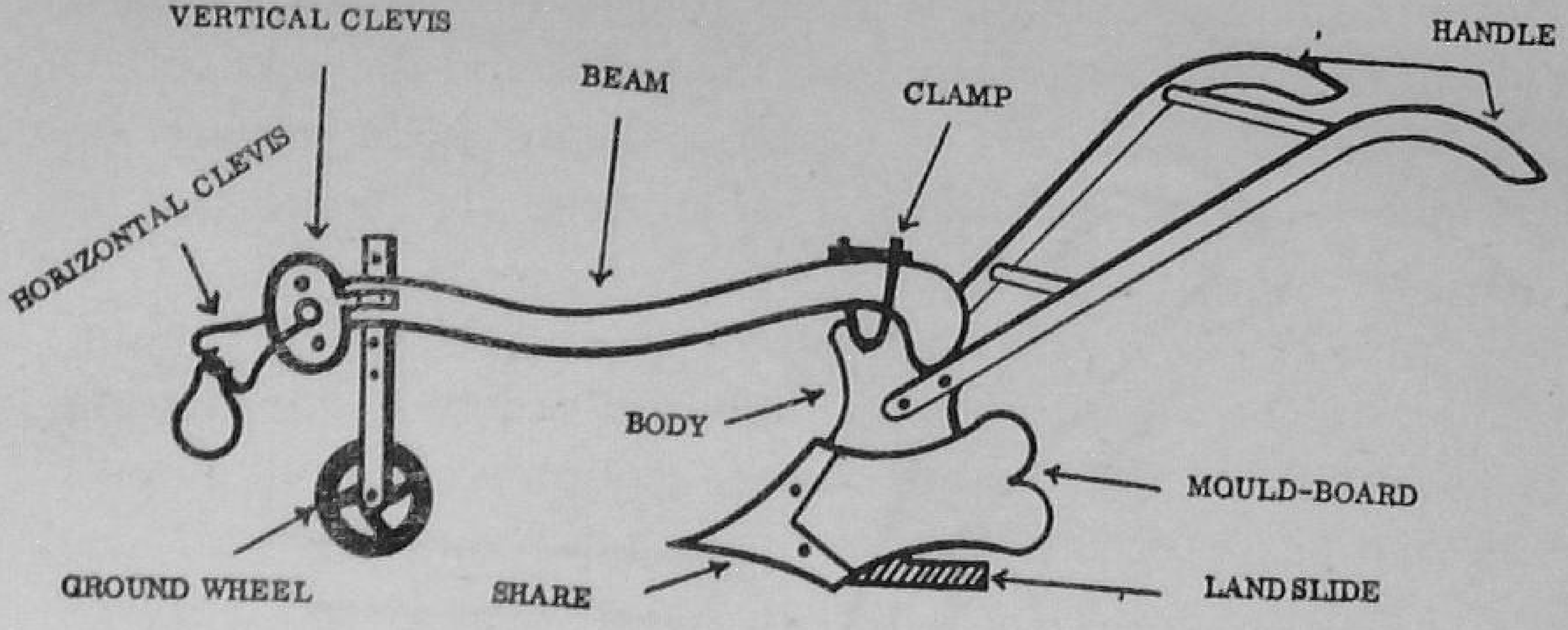
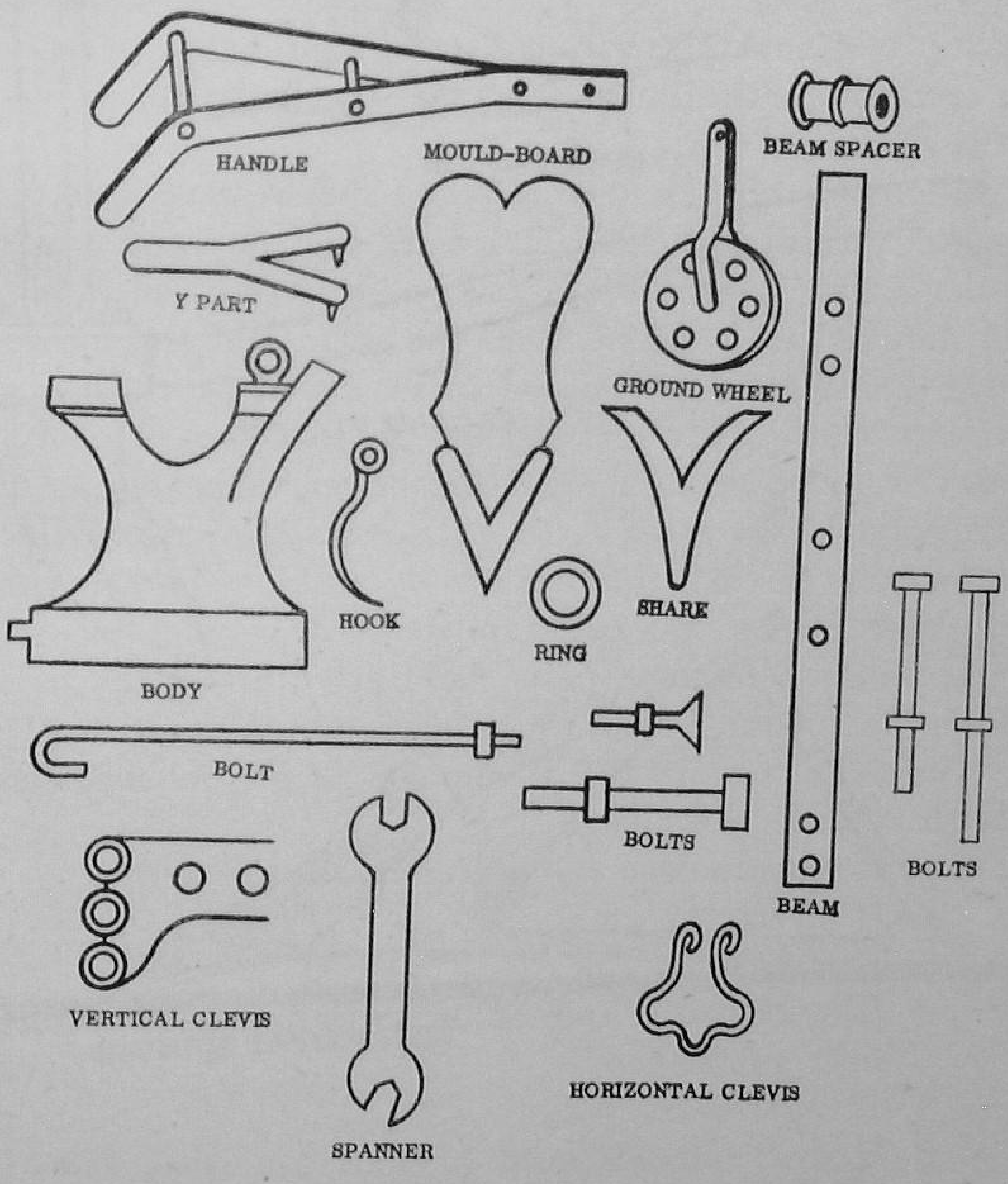
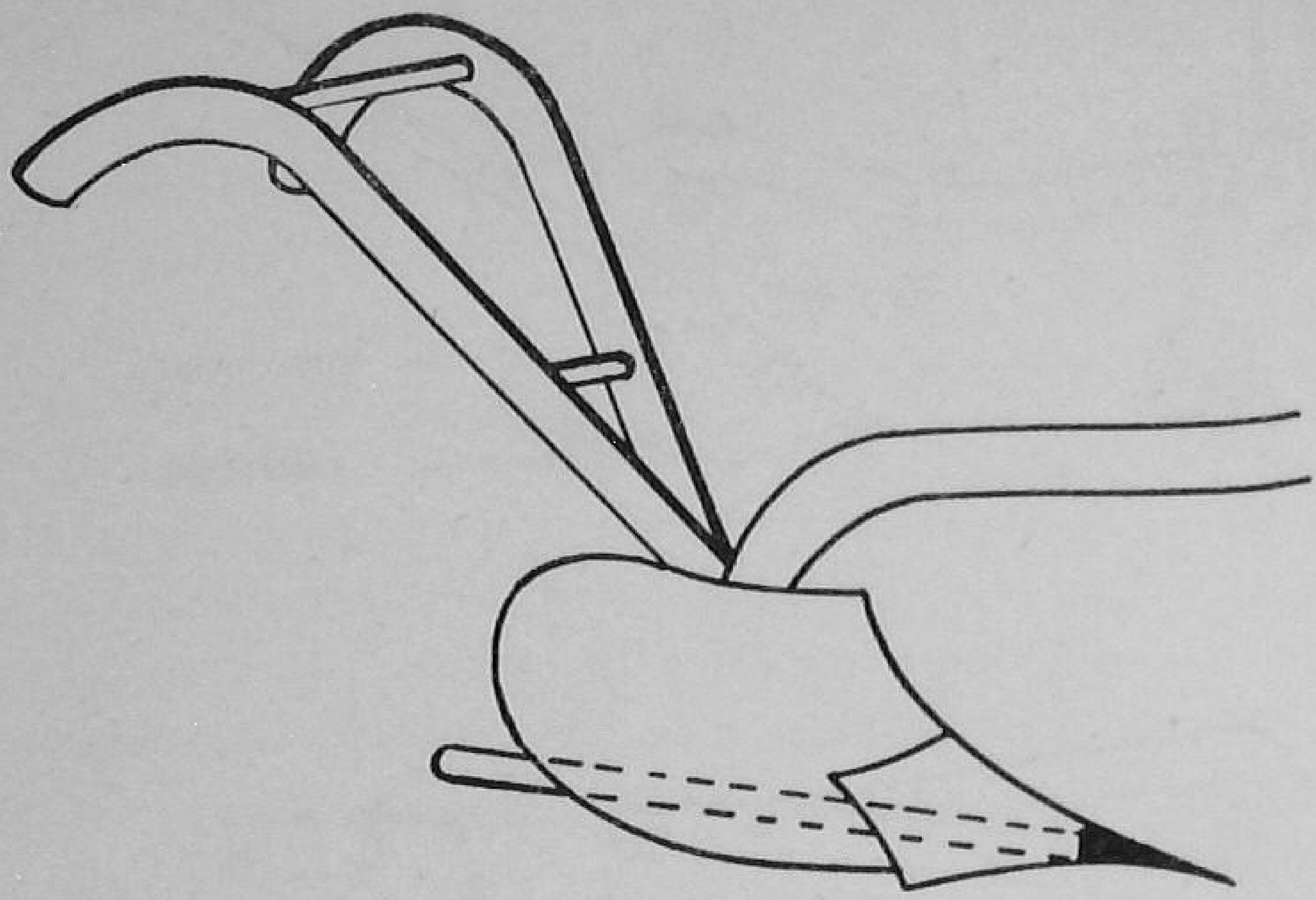
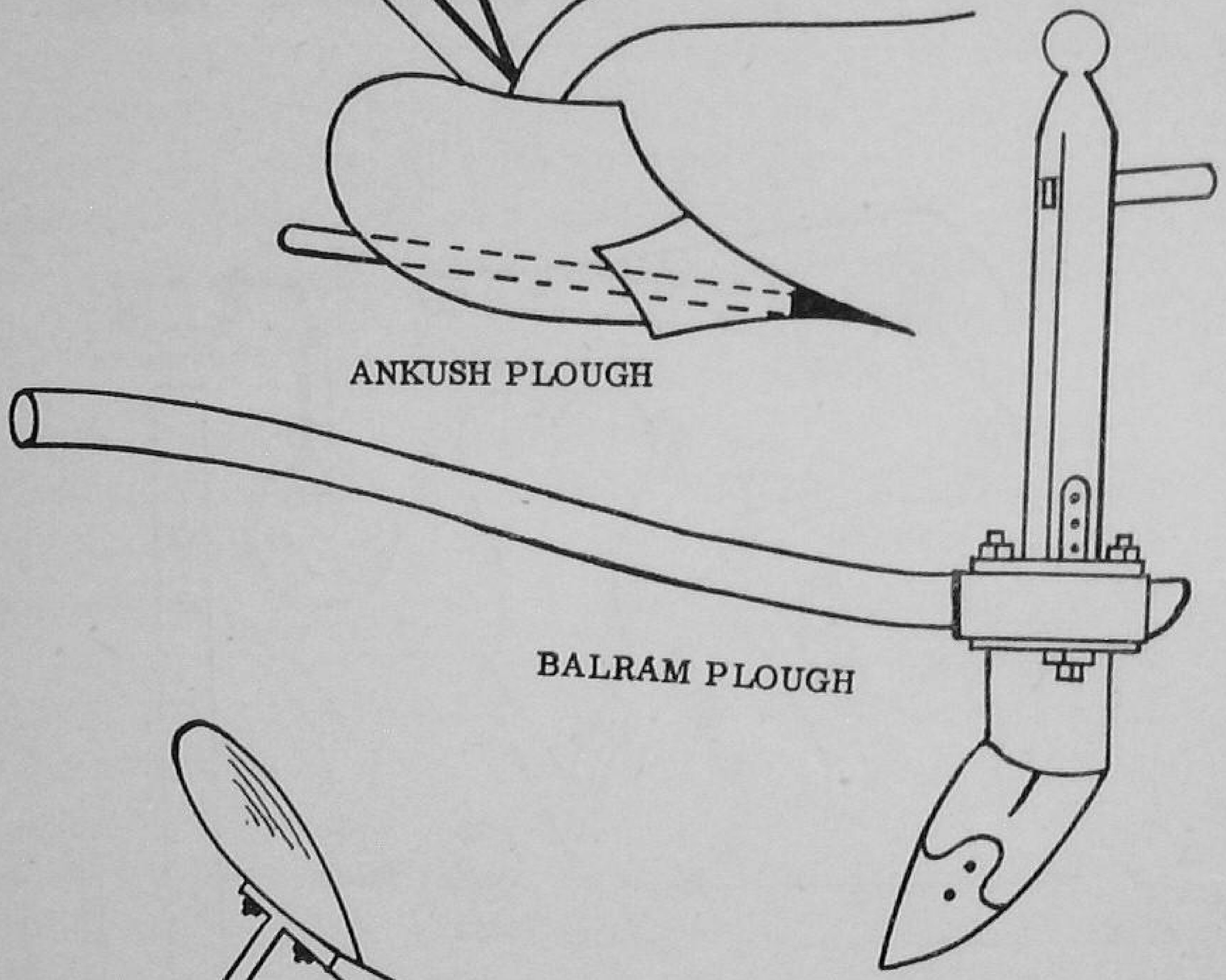




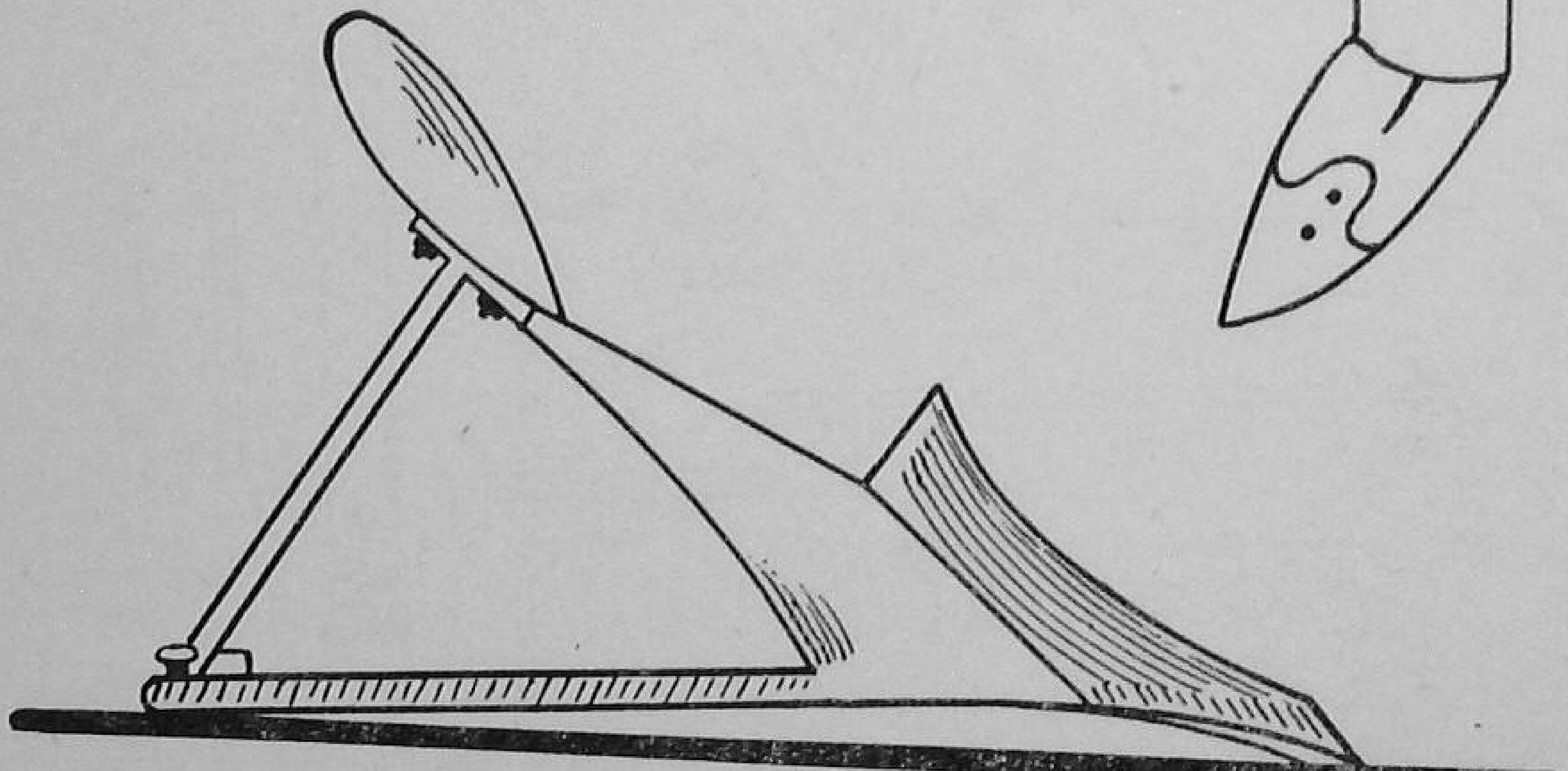
Parts of a Mould-board Plough



ANKUSH PLOUGH



BALRAM PLOUGH



HORIZONTAL SUCTION

Following precautions should be taken while ploughing:

1. Proper adjustment of wheels and clevises.
2. The bullocks should be so yoked that the share point of the plough does not injure their feet.

After ploughing, the share and the mould-board should be cleaned, oiled and stored in a shed so that they do not get rusted.

A description of some mould-board ploughs is given below.

LIGHT MOULD-BOARD PLOUGH: A pair of small bullocks can draw a light mould-board plough. It is used for ploughing and puddling paddy fields. It has a long wooden beam, which can be easily fastened directly to the yoke. For adjusting the depth of ploughing, a wedge is provided with the clamp. The depth obtained is 3″ to 4″ and the width 4″ to 6″. The weight of the plough is about 45 lb. It costs between Rs. 15 and Rs. 25.

MEDIUM MOULD-BOARD PLOUGH: A medium mould-board plough is suitable for alluvial soils. The Malwa plough, the Care plough, etc., are examples of a medium mould-board plough. They require a pair of good bullocks. The Monsoon plough and the Malwa plough have a replaceable share point of forged tool steel. The furrow capacity of these ploughs is 4″ to 6″ deep and 7″ to 9″ wide. Their approximate weight is 50 to 60 lb. and their price ranges from Rs. 30 to 45. The depth can be adjusted by a clamp provided on the beam. Somewhat bigger ploughs in this group are the Punjab plough, the Victory plough, and Kirloskar No. 11. The furrow capacity of these ploughs is 5″ to 6″ deep and 9″ to 10″ wide. Their approximate weight is 70 to 110 lb. They require a pair of very good bullocks.

For stony soils, an adjustable high grade steel bar is used as share on some ploughs such as the Ankush plough. This bar passes through the entire length of the body and is held rigidly in position by means of a tapper key. The bar has both its ends pointed which can be easily resharpened by a village blacksmith. These ploughs are used to break hard-pan formations and for earthing up the sugarcane crop. They require one to two pairs of bullocks. The furrow capacity of

such ploughs is 4″ to 7″ deep and 6″ to 10″ wide. The Ankush plough weighs about 155 lb.

Turn-wrest Ploughs

In ordinary mould-board ploughs, the mould-boards are fixed rigidly to the body. They have to be driven round and round along the periphery of the field slowly moving to its centre, or vice versa from the centre to the periphery.

Turn-wrest ploughs are so constructed that their mould-boards can be swung round both the sides of the body. In this way straight ploughing can be done by turning the mould-board on the other side of the body every time one trip is completed. Thus, the furrow on the return trip can be opened up on the same side. A few turn-wrest ploughs are described below.

Kirloskar Turn-wrest Plough No. 15: This is a medium type plough, useful in black cotton soils. It can be worked by two pairs of ordinary bullocks and is slightly larger than the Kirloskar Plough No. 11. Its furrow capacity is 7″ to 10″ deep and 10″ to 12″ wide. The weight of the plough is 141 lb.

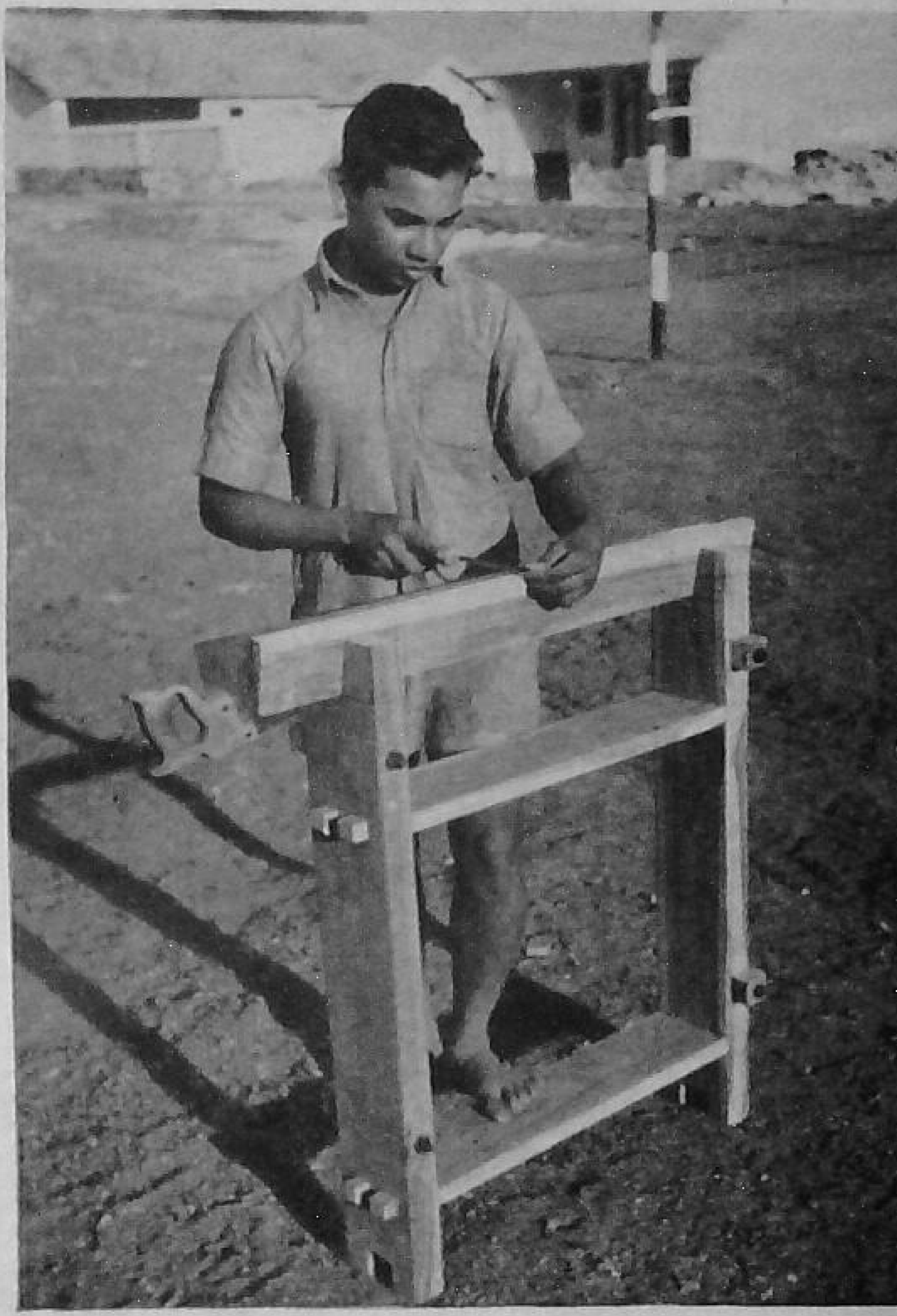
Kirloskar Turn-wrest Plough No. 100: This is one of the popular heavy ploughs in the black cotton soil areas. It is also suitable for medium soils as well as soils which are under irrigation. It requires two to three pairs of bullocks. Its mould-board is designed to completely invert the soil. The depth at which the plough works is 6″ to 8″, and the width of the furrow it opens is 10″ to 15″. Its weight is 190 lb.

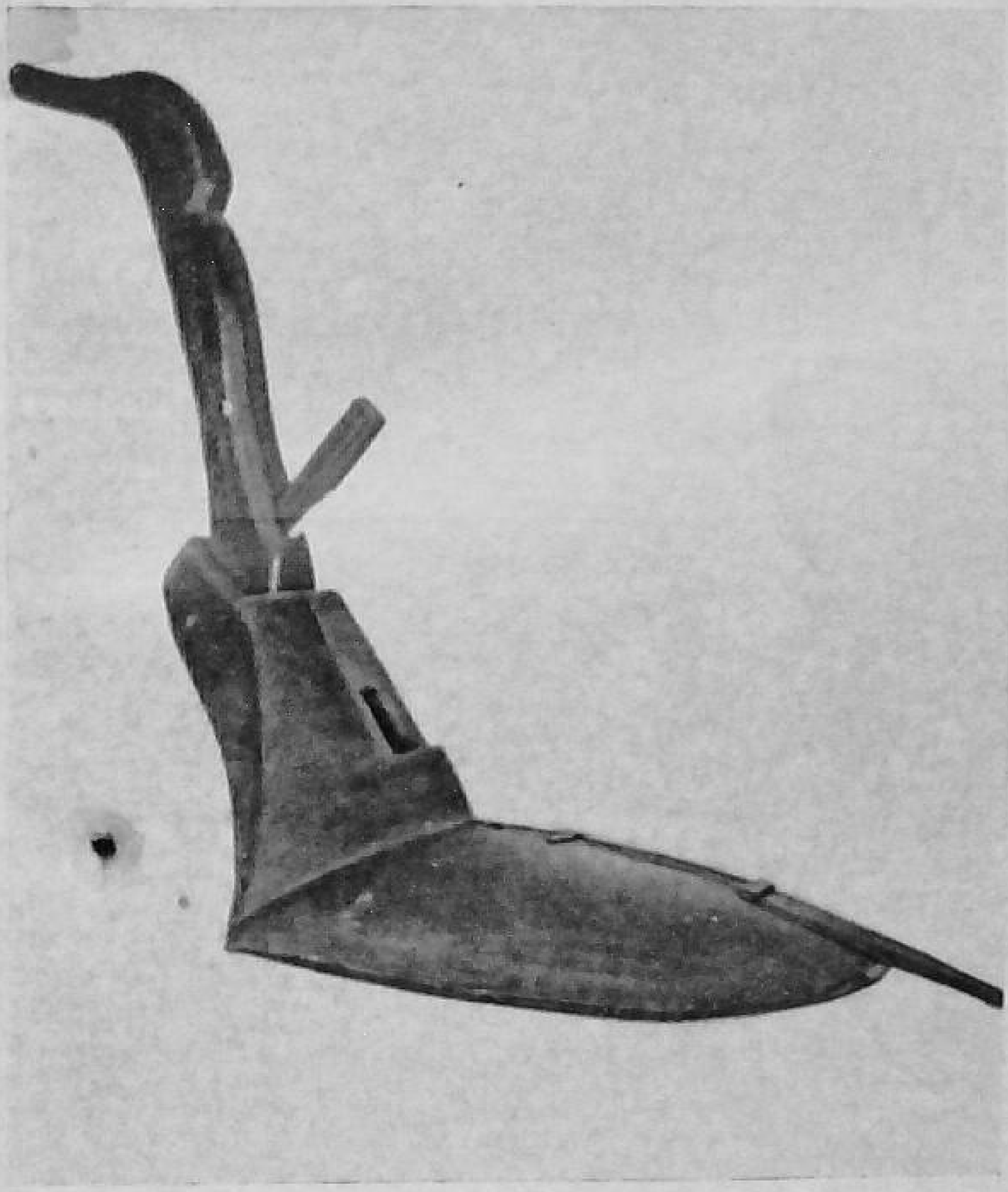
Kirloskar Turn-wrest Plough No. 8: This is one of the heaviest ploughs and is useful for heavy black cotton soils and sugarcane lands. It is sturdier than No. 100 and No. 9. It requires four to five pairs of bullocks. Its furrow capacity is 8″ to 16″ for depth and 15″ to 18″ for width. The weight of the plough is 219 lb.

Ridging Ploughs

Kirloskar Jayant ridging plough, Allahabad ridger, Cossul ridger, etc., are light ridging ploughs. Though small,

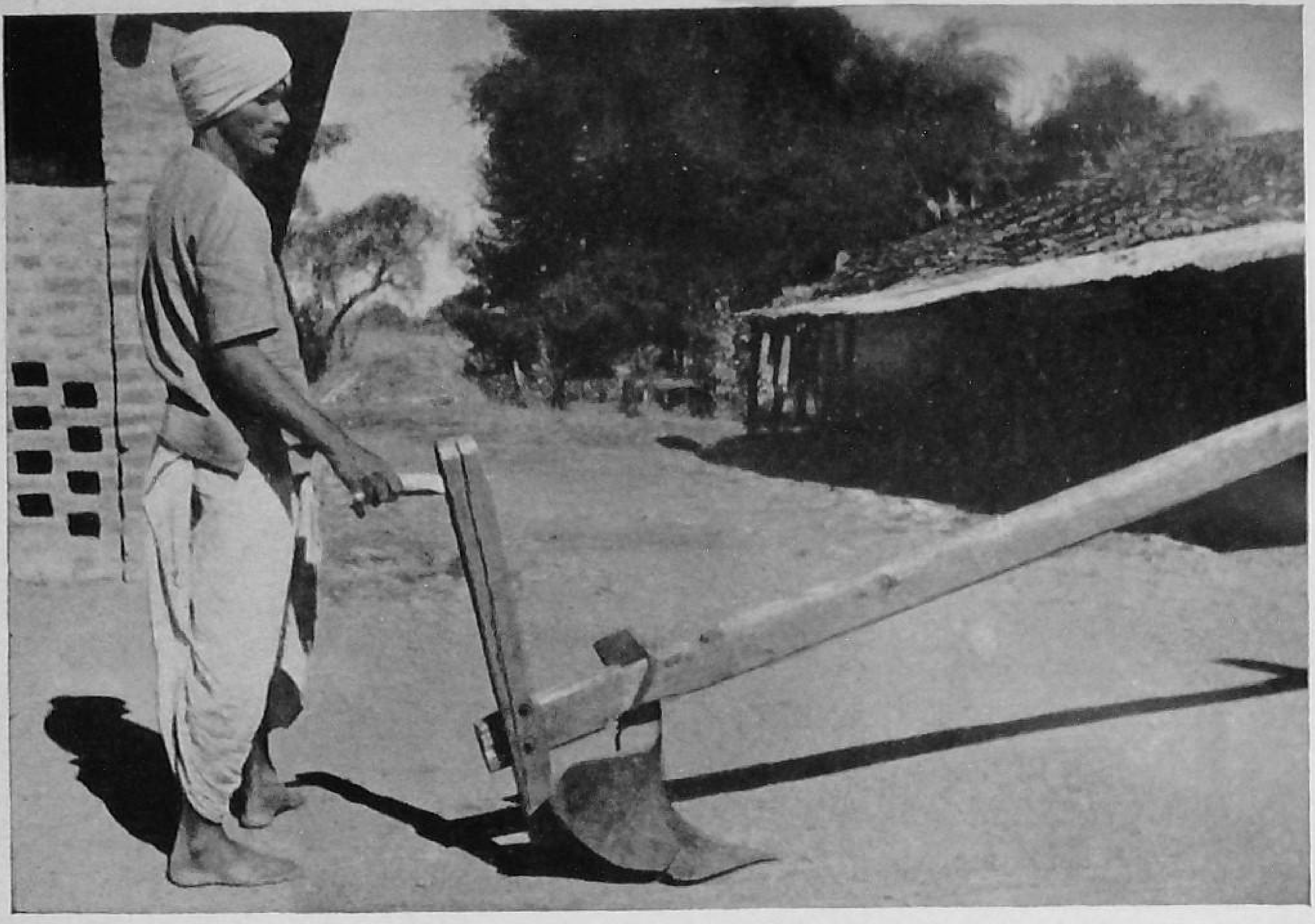
A Village Level Worker Trainee Learning How to Sharpen a Saw





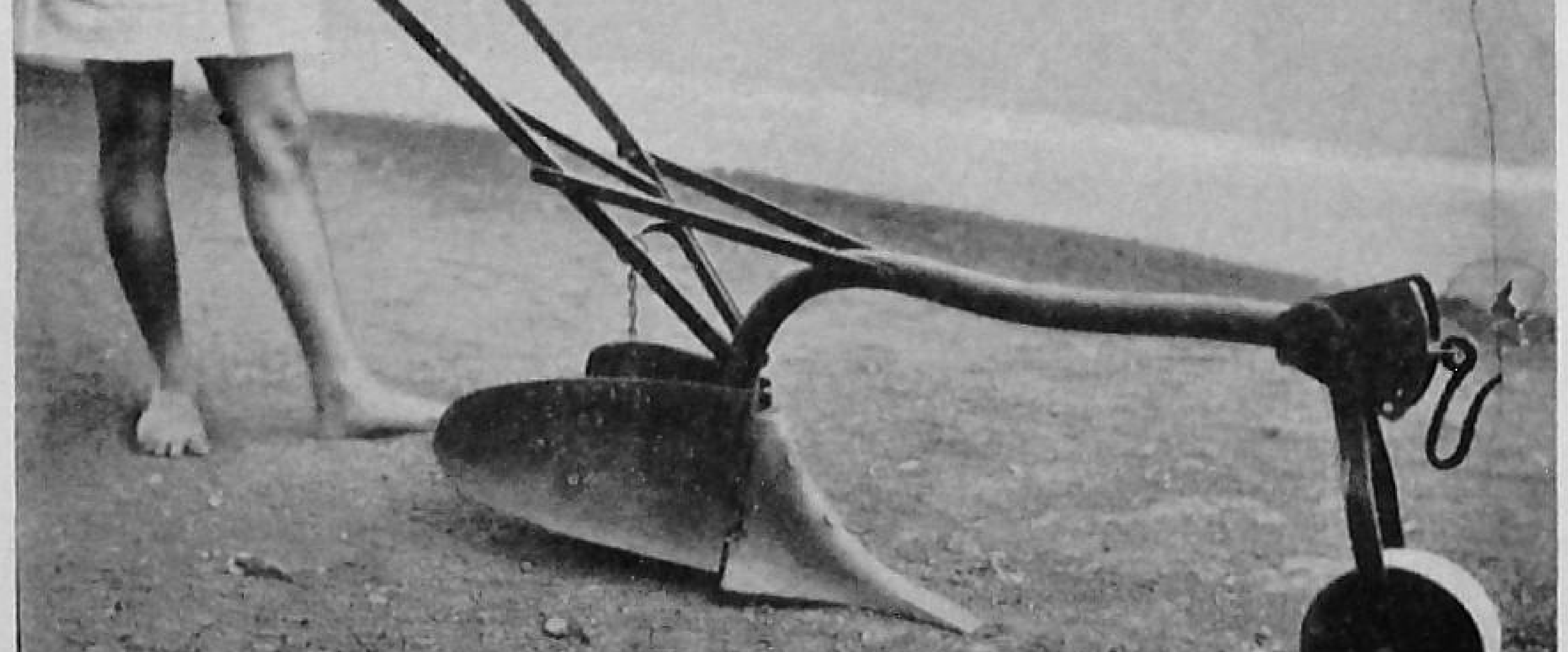
A Duck-foot Plough

A Standard Desi Plough



A Medium Mould-board Plough

A Light Ridger



they are sturdy and are popular for ridging and furrow-making for the vegetable and garden crops such as chillies and tomato. They can turn a furrow 8″ to 9″ deep and 20″ to 22″ wide. They weigh about 60 to 65 lb. The share points of some of the ridgers are renewable, and their mould-boards are rivetted. In some, an adjustable pole is provided for depth adjustment.

The medium and heavy ridging ploughs weigh between 90 lb. and 245 lb. The heavier ploughs are suitable for crops such as sugarcane, sweet potatoes, etc. The width of the furrow can be adjusted in these ploughs by two straps or yoke poles provided at the back of the mould-boards. The heavy ridging ploughs require two to three pairs of bullocks. Their furrow capacity is from 2′ to 3½′ wide. Their steel beams have enough clearance to allow the soil to pass through easily.

Chapter 4

CULTIVATORS AND HARROWS

After ploughing, the next operation undertaken by a farmer is of breaking the clods into small pieces. This is done by means of implements called cultivators and harrows. In some areas where the soil has been under cultivation for years, ploughing is considered unnecessary and the land is prepared for sowing only by using the cultivators or the harrows. They are worked on the soil once or more as required.

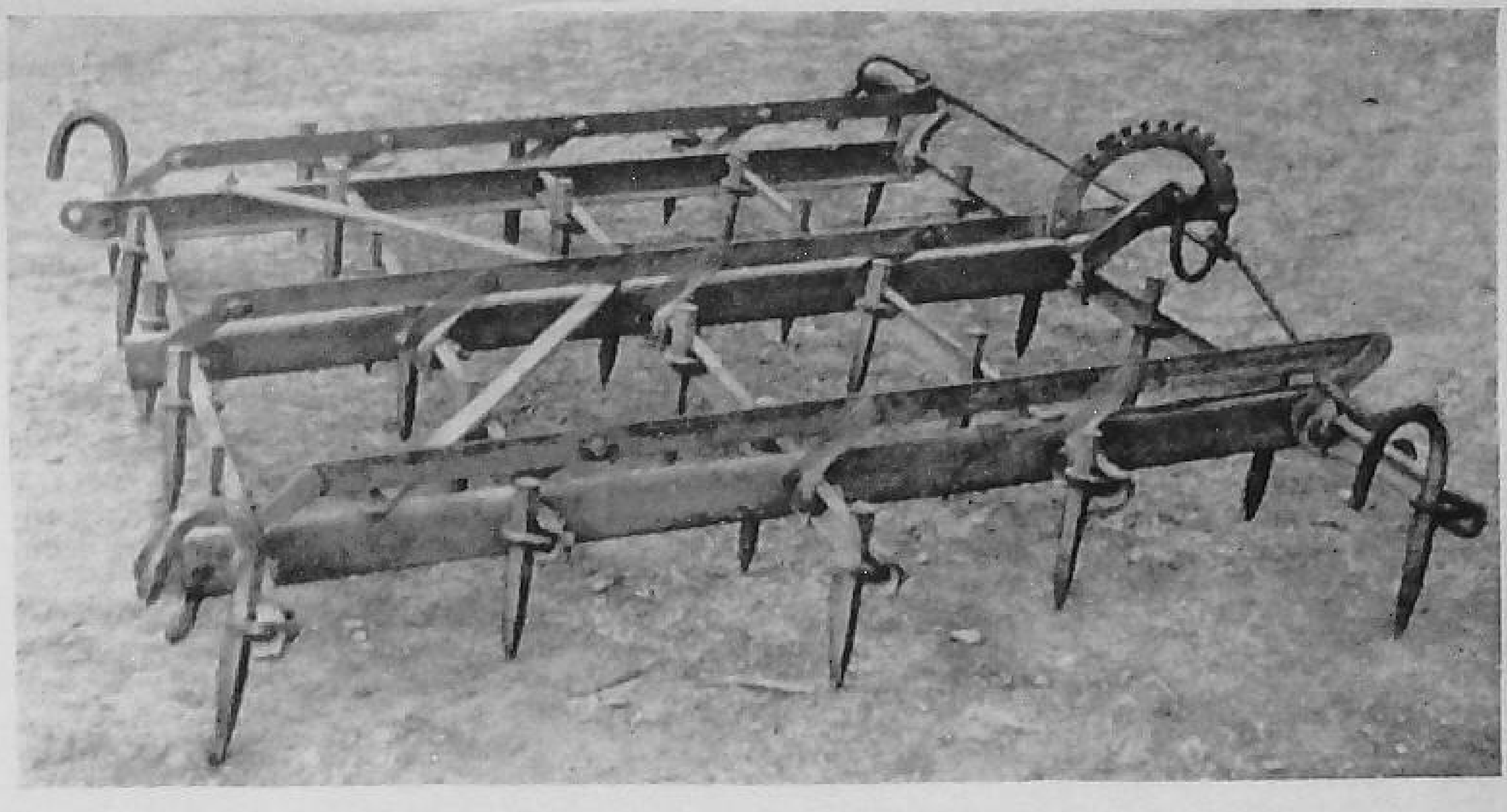
Cultivators are usually heavier than harrows and hence work the soil deeper. The heavy *bakhar* used in the Deccan is a good example of such a cultivator. When this implement is worked in hard soils, the farmer usually stands on it to give it weight and obtain a good penetration of the blade. The ordinary *bakhar* is termed as a bladed harrow.

The steel blade of a *bakhar* may be serrated and may have a concave or a convex shape depending on the custom in the locality. However, it has been observed that a blade slightly bent towards inside in the centre gives a better penetration. The blade is fixed to the tines by means of rings. When the implement is worked in slightly wet soils, the soil and weeds stick to it, and it has to be cleaned by means of a scraper.

Cultivators and harrows can work the soil 2½″ to 5″ deep, pulverize it, cut the weeds and thus prepare a seed-bed. The weeds should be immediately picked up from the field after they are cut. The width of bullock-drawn modern cultivators and harrows ranges from 2′ to 4′. They can cover two to five acres a day.

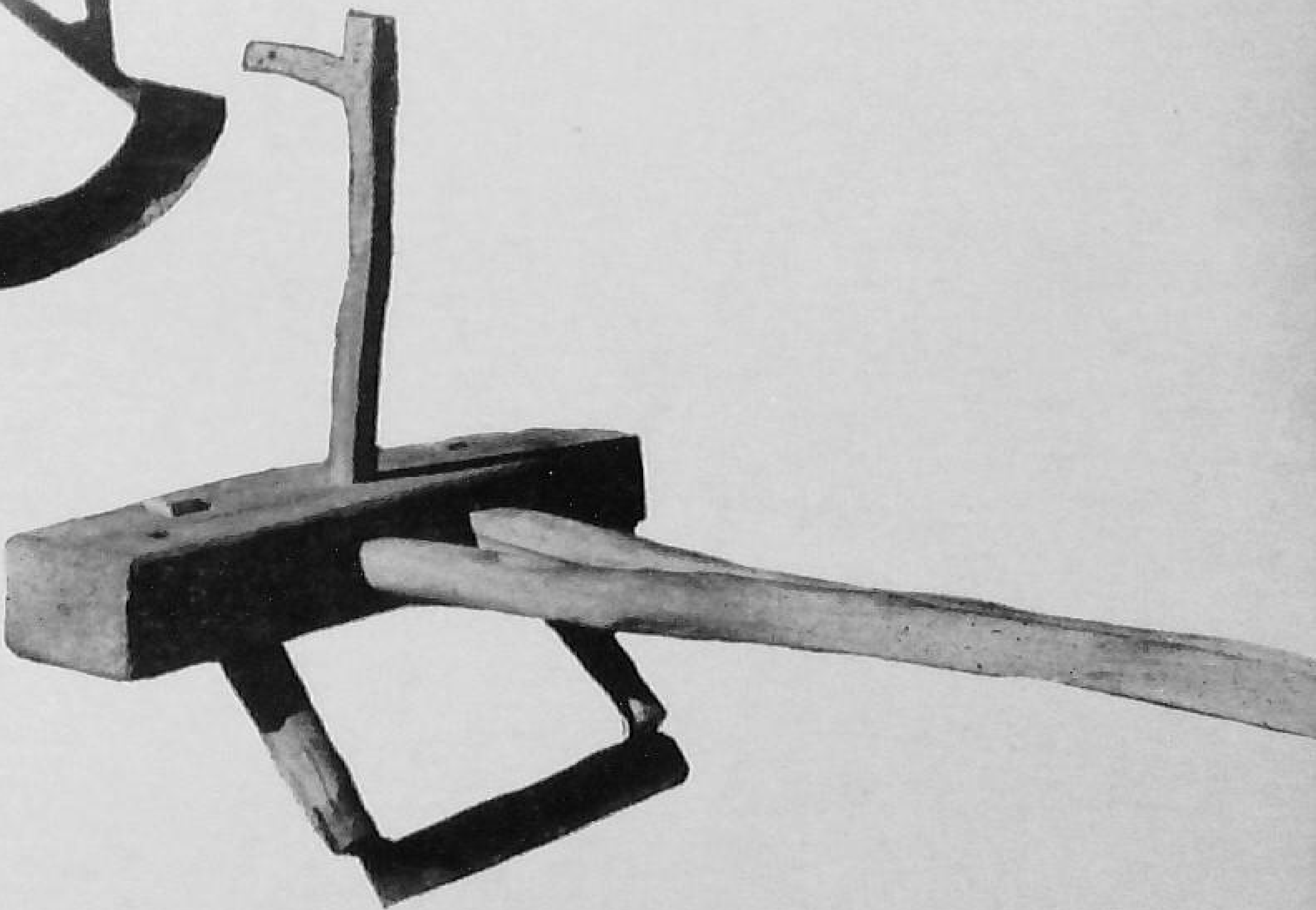
The following are some of the improved implements of this type.

Guntakas or Steel Bakhars: The *guntaka* designed by the Department of Agriculture, Madras, has a blade made

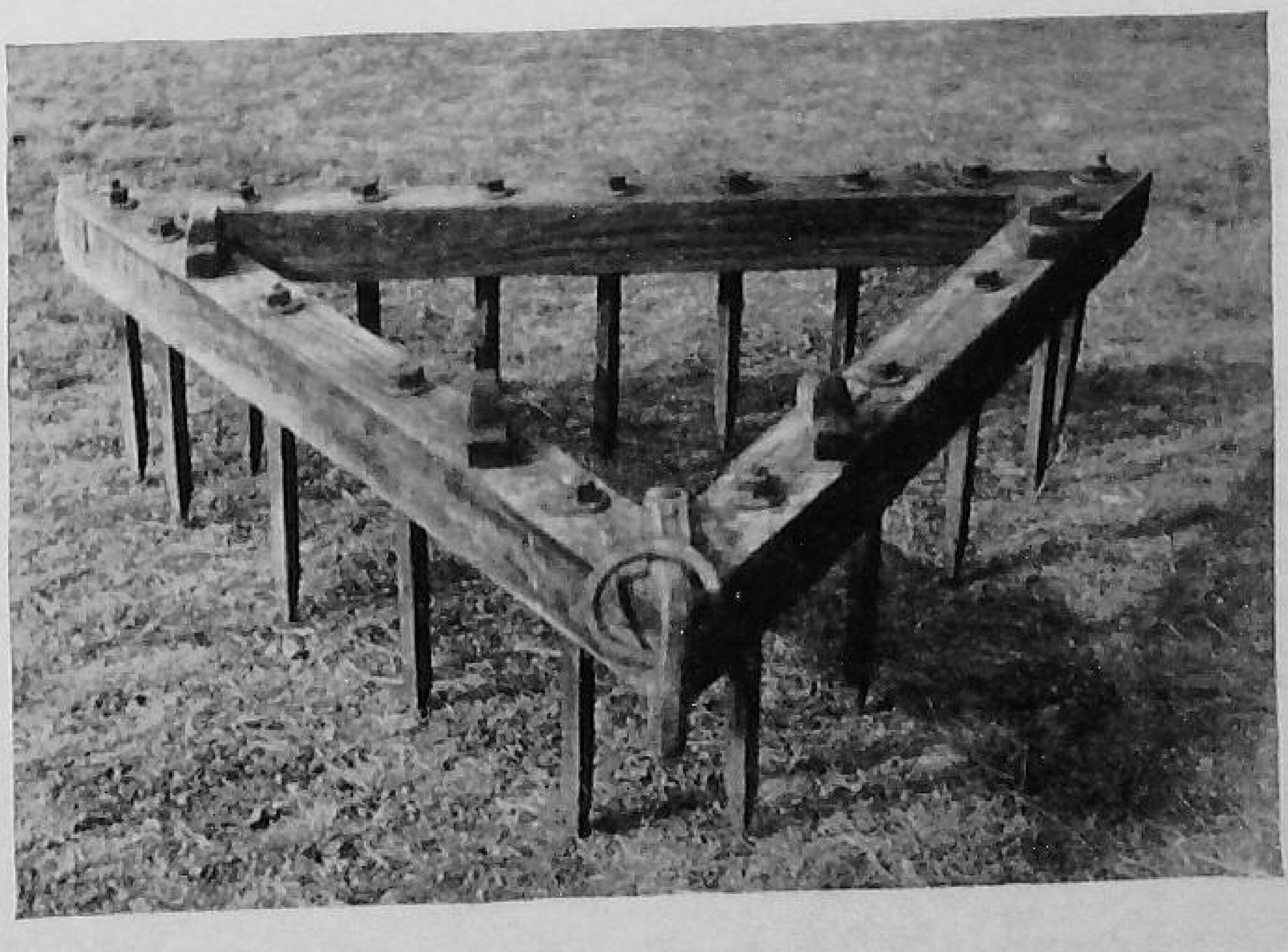


A Spike-tooth Harrow

A Guntaka Designed by the Madras Agricultural Department

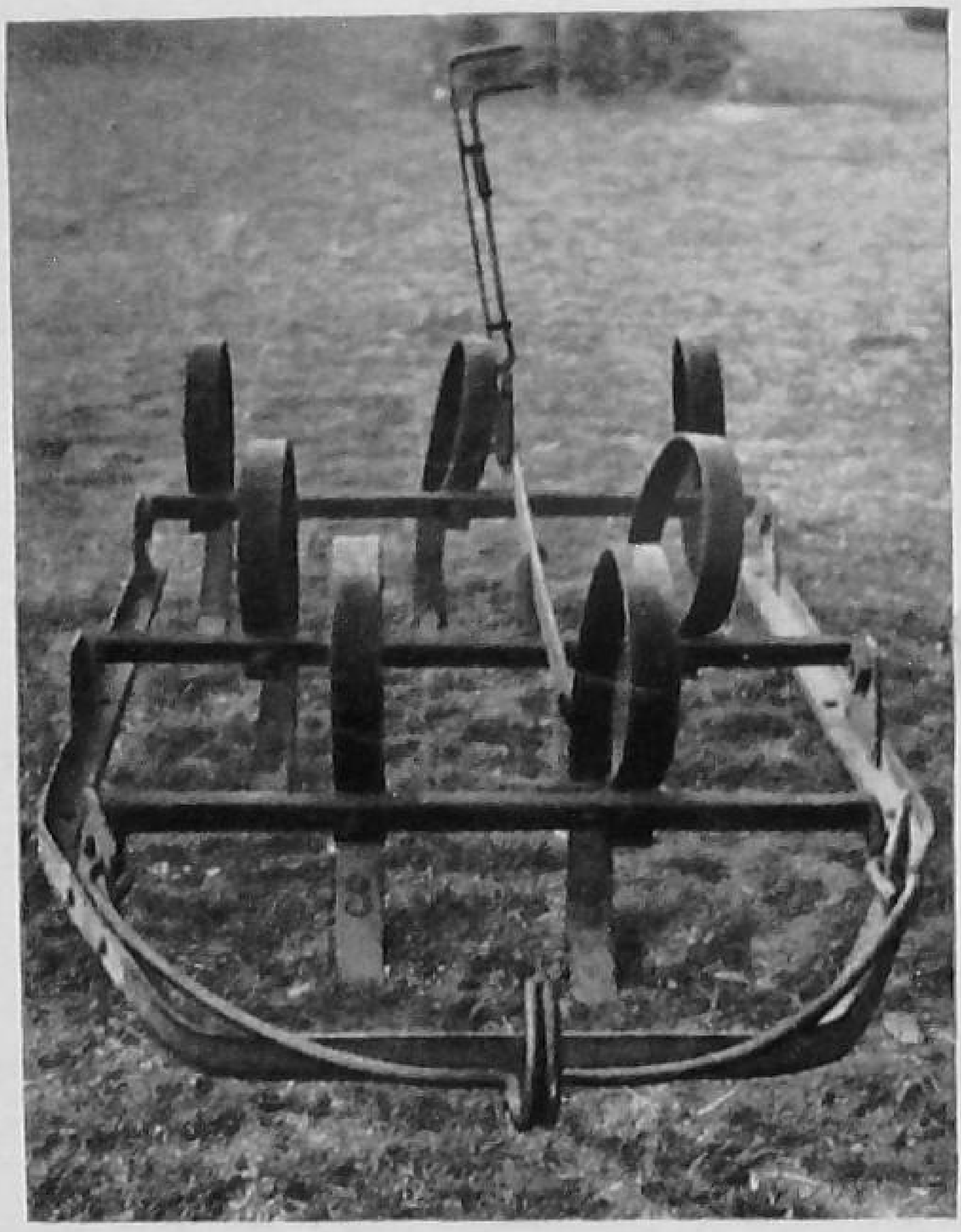


A Heavy Deccan Bakhar

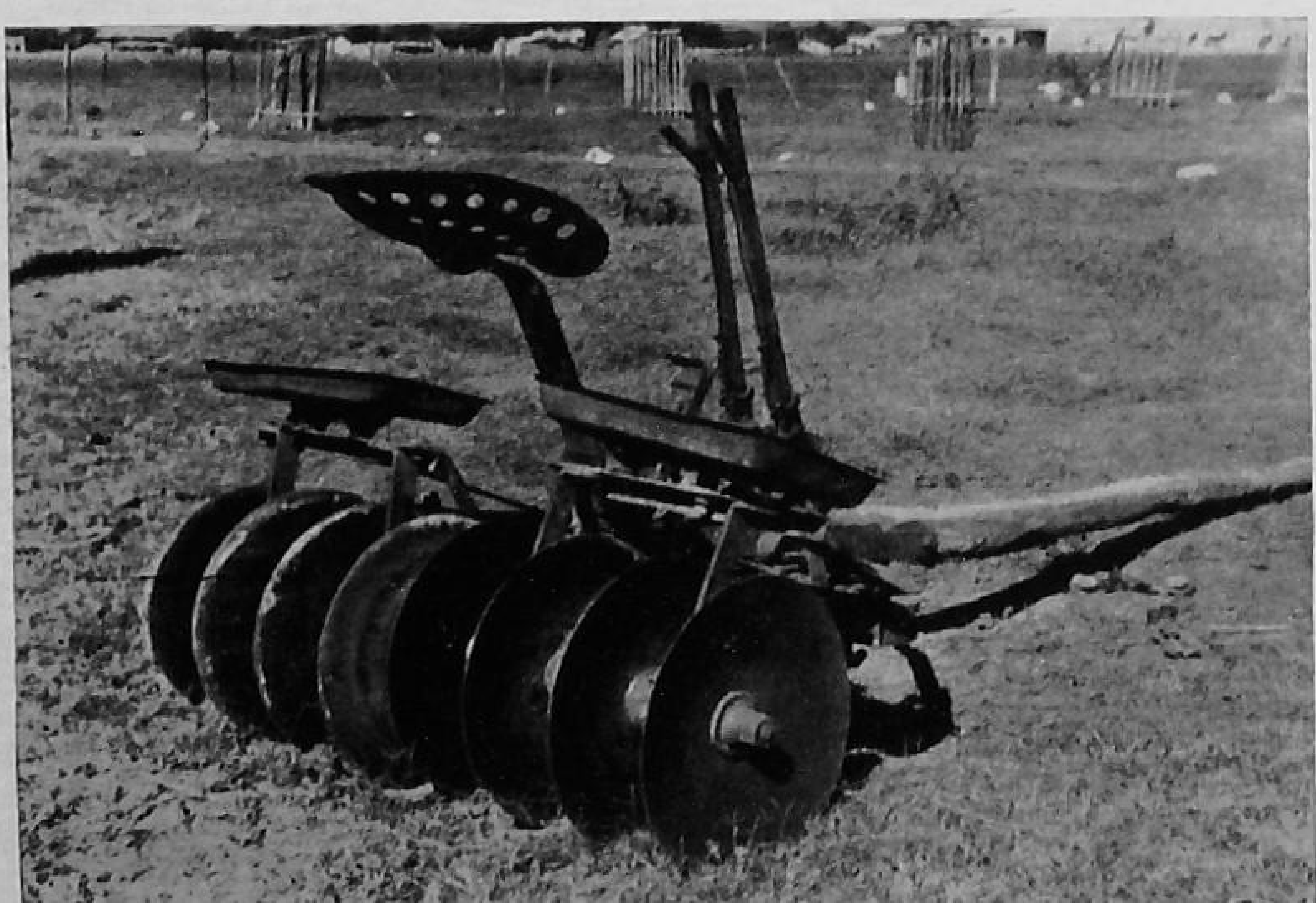


A Triangular Peg Harrow

A Tined Cultivator



A Spring-tooth Harrow



A Disc Harrow

from spring steel to ensure a long life and durability. The size of the blade is 26″×3″×½″ and its angle can be changed by using the four holes provided on the tines. The approximate weight of the steel parts of this implement is 40 to 45 lb.

The blade cuts a ribbon of the soil and deposits it down, forming soil mulch. This implement is used to break the soil crust after rains, to cover and mix manure, and also to lift up groundnut pods in soft soils.

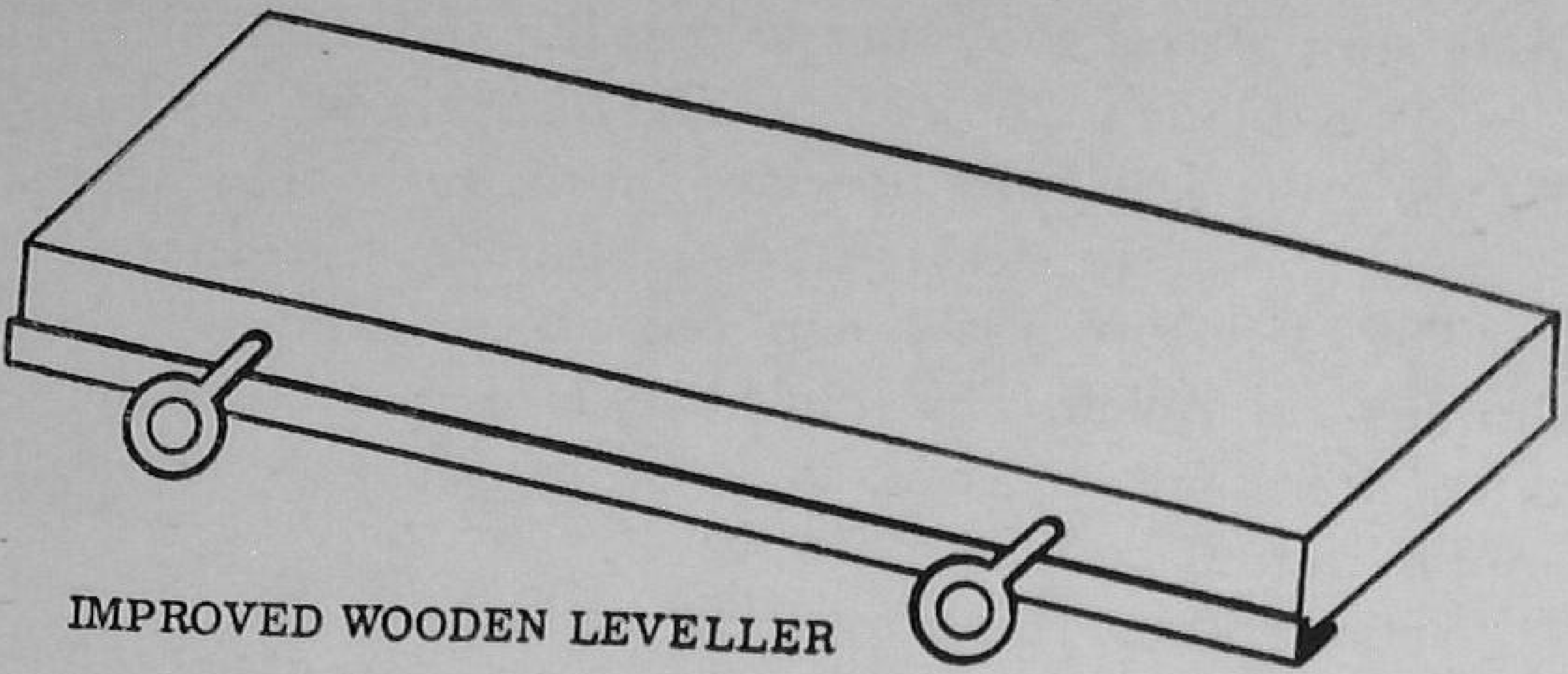
SPIKE-TOOTH HARROW: The spike-tooth harrow has a number of pointed pegs or spikes fixed on a framework. A lever is provided to change the angle of the spikes to suit the hardness of the soil. This also enables the harrow to be clear of trash and weeds.

Usually, 25 to 30 teeth are provided on the harrow suitable to be pulled by a pair of bullocks. The width of a spike-tooth harrow is 30″. On the four corners of the implement, hooks are provided so that it can be carried from place to place easily, after placing it on the ground on these hooks.

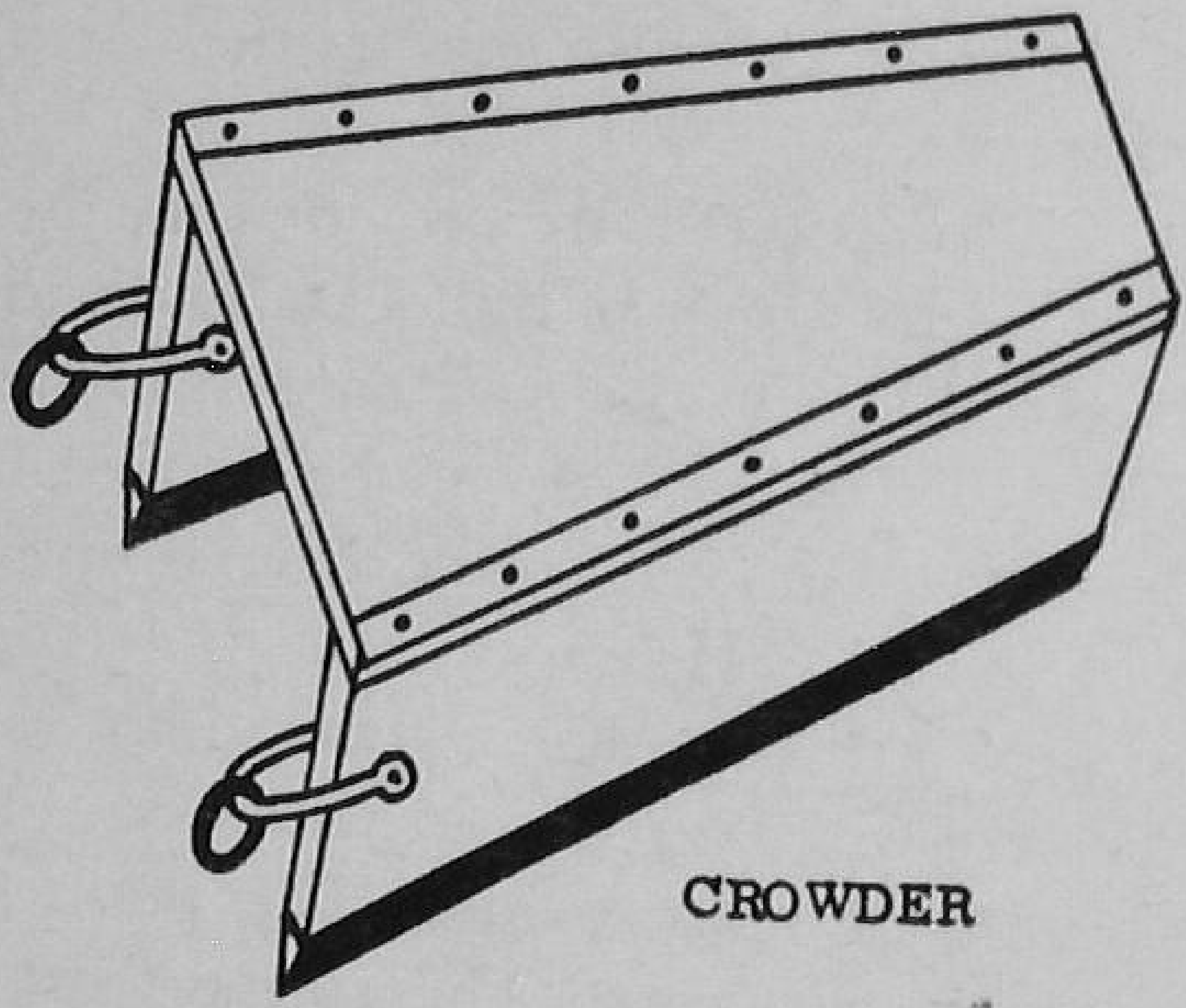
TRIANGULAR PEG HARROW: In the triangular peg harrow the pegs are bolted to a triangular wooden frame. They can be removed or replaced with ease. On a 30″ wide frame, 15 to 18 teeth are provided. The outfit weighs 54 lb.

SPRING-TOOTH HARROW: The spring-tooth harrow is a single section harrow, fitted with spring tines of flat sections having hardened double-pointed reversible share points which can be replaced. A depth-regulating lever is provided in the implement. There may be five to seven tines in the harrow. The implement can be pulled by a pair of bullocks, and weighs 102 to 118 lb. Its price ranges from Rs. 90 to 112. About three to four acres can be covered in a day by a spring-tooth harrow.

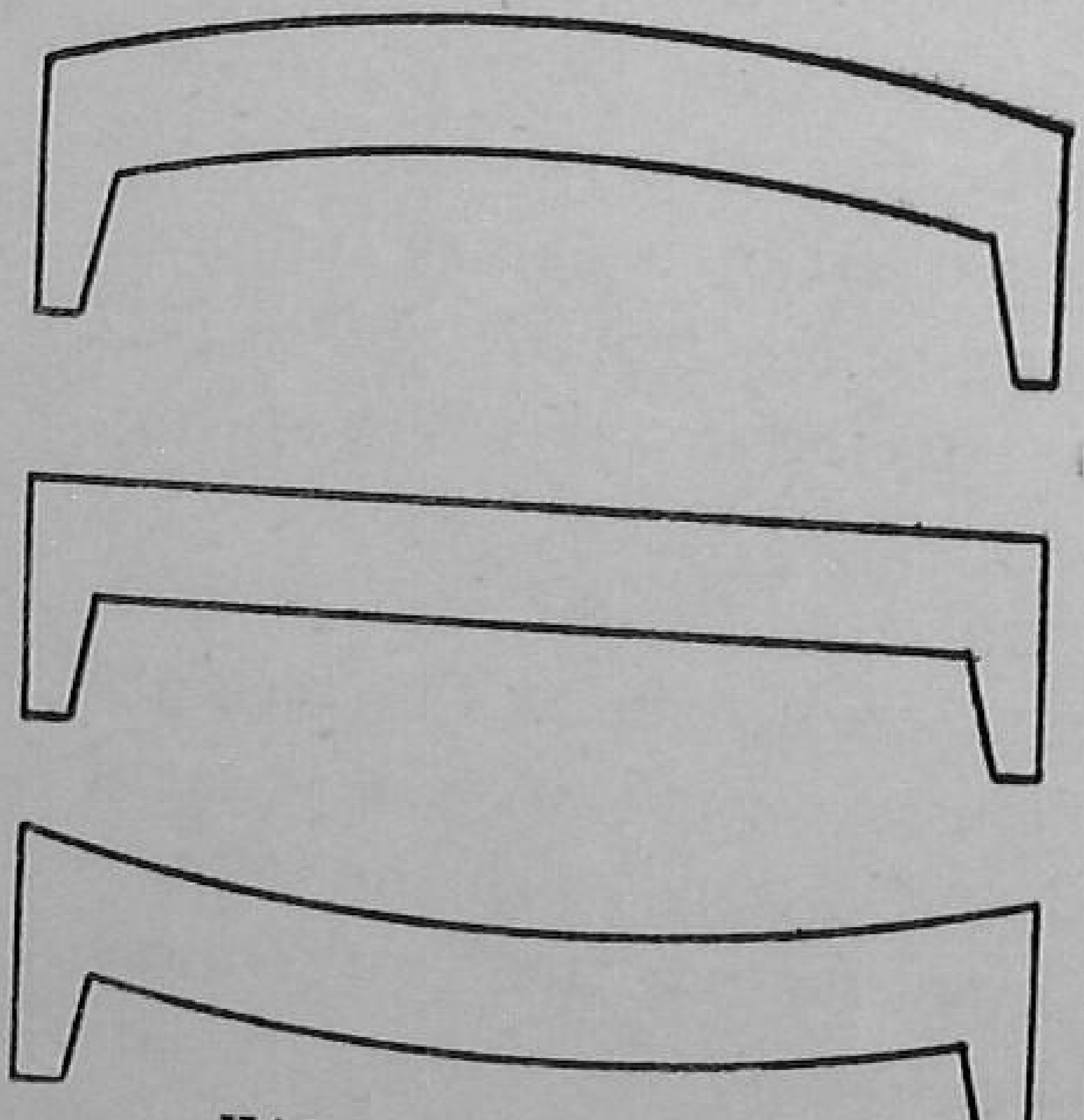
TINED CULTIVATOR: The tined cultivator is used both for harrowing the land and for intercultivating. The distance between the tines of the implement which are either rigid or spring type can be adjusted and altered with the help of a lever. Many firms in India manufacture these cultivators but their basic design resembles that of the Planet Junior Hoe. In good cultivators, an adjustable head wheel is



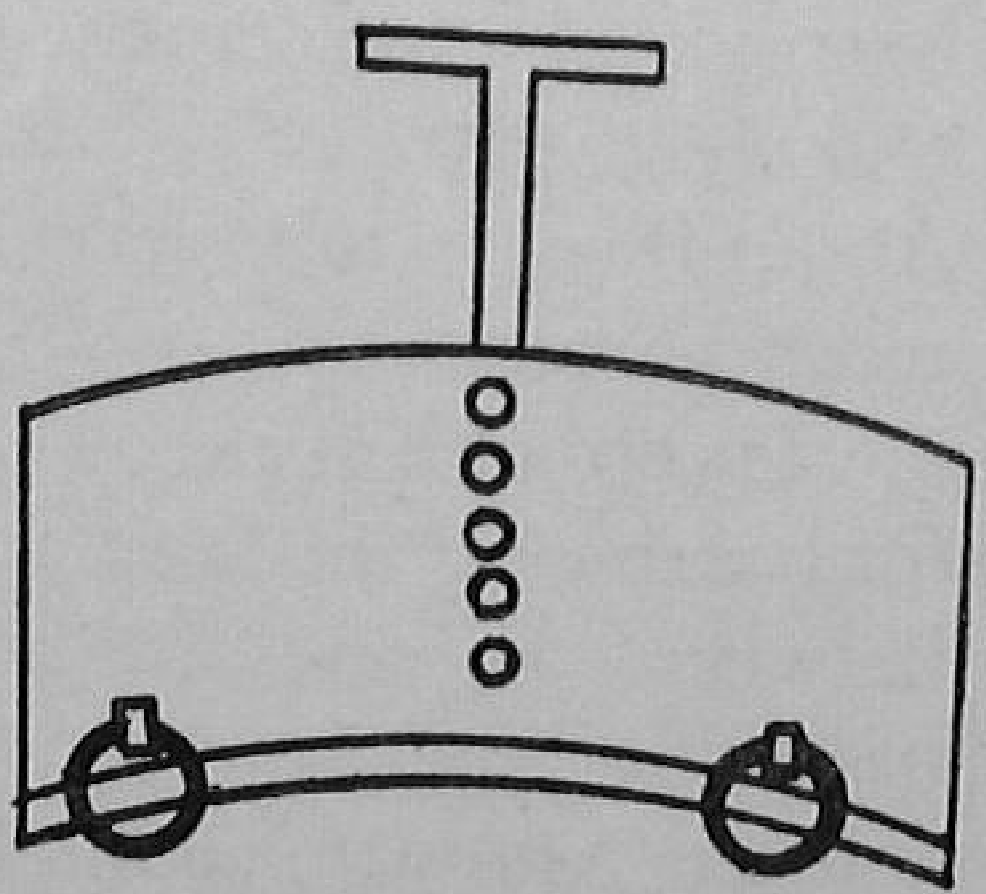
IMPROVED WOODEN LEVELLER



CROWDER



HARROW BLADES



LEVELLING KARAH

provided in the front to give an even depth of cultivation and to make the handling of the implement easy. The approximate weight of such an implement is 80 to 90 lb. The width adjustments can be made from a minimum of 15″ to 18″ to a maximum of 26″ to 30″. The price of a tined cultivator is about Rs. 80. A pair of bullocks is required to work a tined cultivator.

Tined cultivators have become very popular in sugarcane-growing areas. Rigid tines are good for hard soils whereas spring tines are preferred for stony or rocky lands.

DISC HARROW: The disc harrow is efficient but a rather costly implement. It has eight to ten steel discs prepared out of high carbon steel. They are fixed in two gangs which are provided with separate levers for regulating the angle of the discs. A seat is fixed for the operator to ride on the implement. The discs are placed on the axle with spacers and bearings. They should be resharpened when worn out. To be more effective, cut-away discs should be used. One to two pairs of bullocks are required to work this harrow. Its cost ranges from Rs. 300 to 350, and it is able to harrow three to four acres a day.

CHAPTER 5

LEVELLING, AND SOIL AND WATER CONSERVATION IMPLEMENTS

This group of implements comprises buck-scrapers, bund-formers, green manure tramplers, levellers and rollers which are used after the preliminary cultivation of the land is over.

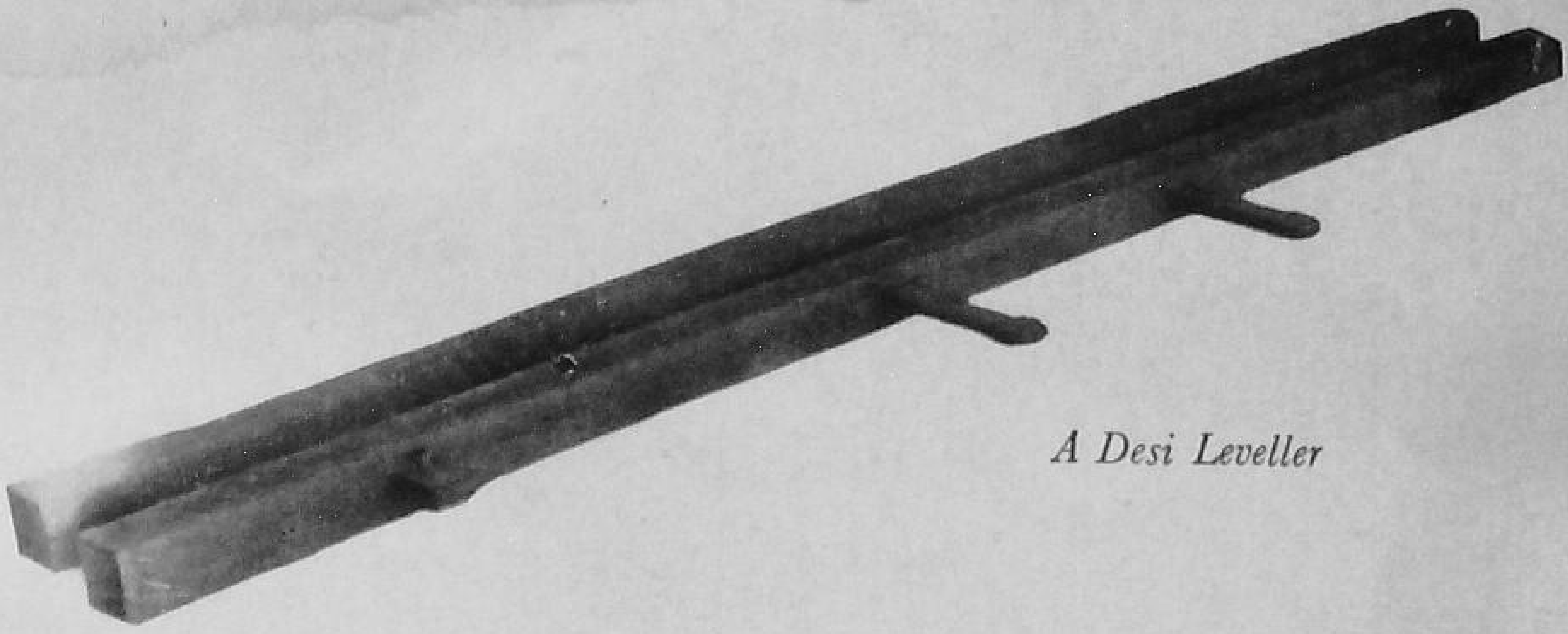
LEVELLERS: The indigenous implement used for levelling the land and for crushing clods after ploughing and harrowing, is a flat log of wood or two square beams of wood joined together which are pulled by a pair of bullocks. If necessary, a man is made to stand on the implement to give it weight. The approximate cost of such a leveller is Rs. 4.

A stone or heavy wooden roller is also used as a leveller in some parts of the country.

Improved types of levellers have an angle iron fixed on the front edge. A levelling *karah* is made from steel sheet. It weighs about 50 lb. and costs about Rs. 35.

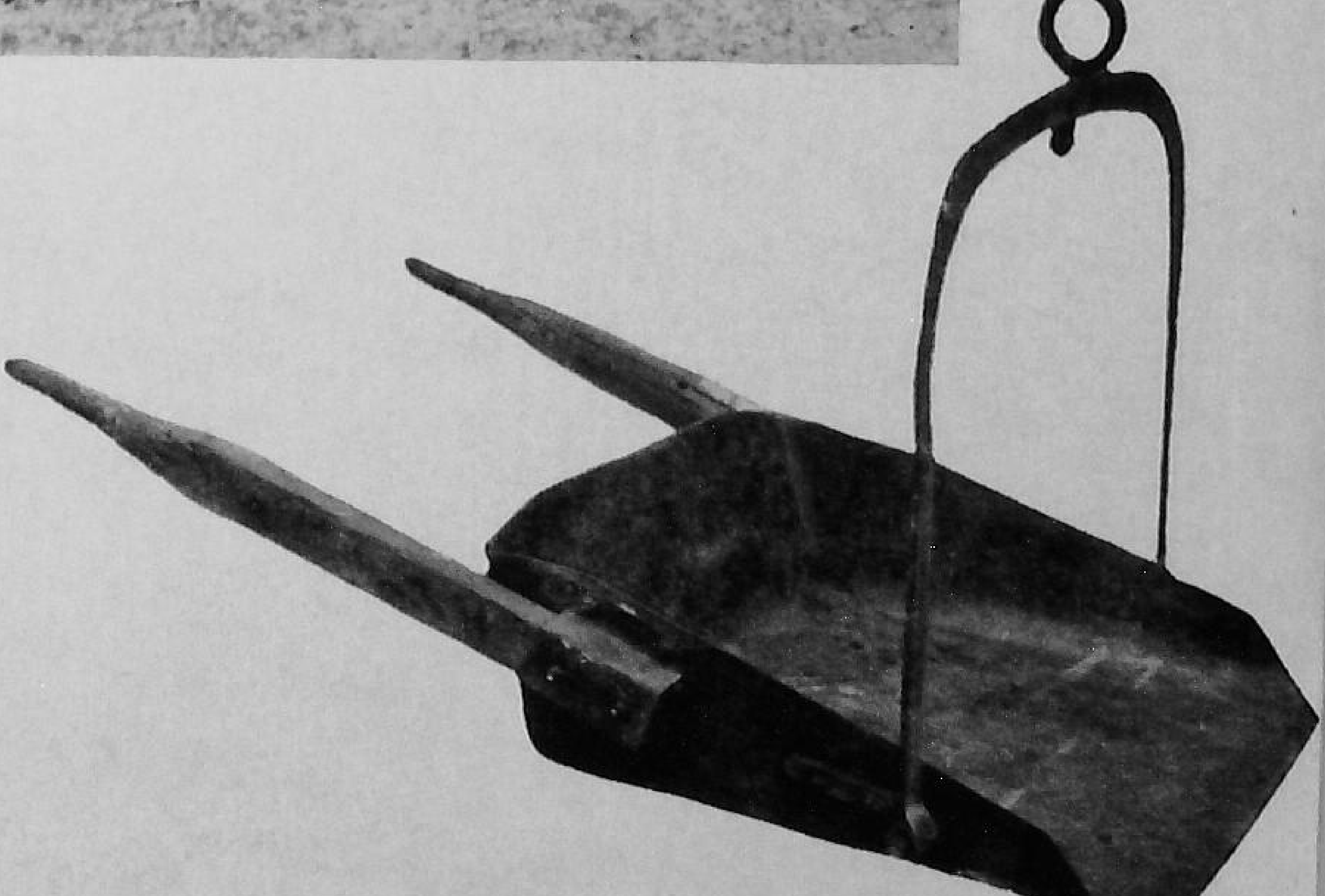
BUCK-SCRAPERS OR SCOOPS: The buck-scraper is extensively used for levelling land, for bunding and for other operations in which a large quantity of earth is required to be moved. The usual capacity of a bullock-drawn model is two to three cubic feet.

Buck-scrapers may have plain or serrated edges. A three-cubic-foot scraper weighs approximately 100 lb. The cutting edge of a scraper should be made of high carbon steel and it should be either welded or rivetted to the pan. The scraper pan should be made from 3/16″ steel sheet with reinforcement at corners. A wooden handle should be fixed to the scraper, as it does not get hot in summer. The scraper pan base should be fitted with two iron plates parallel to each other and at right angles to the scraping edge in order to reduce wear and tear and to decrease draught. In better models, two sharp steel points are fixed on the corners to absorb the shock when the pan filled with soil, is turned upside down.



A Desi Leveller

A Bund Former

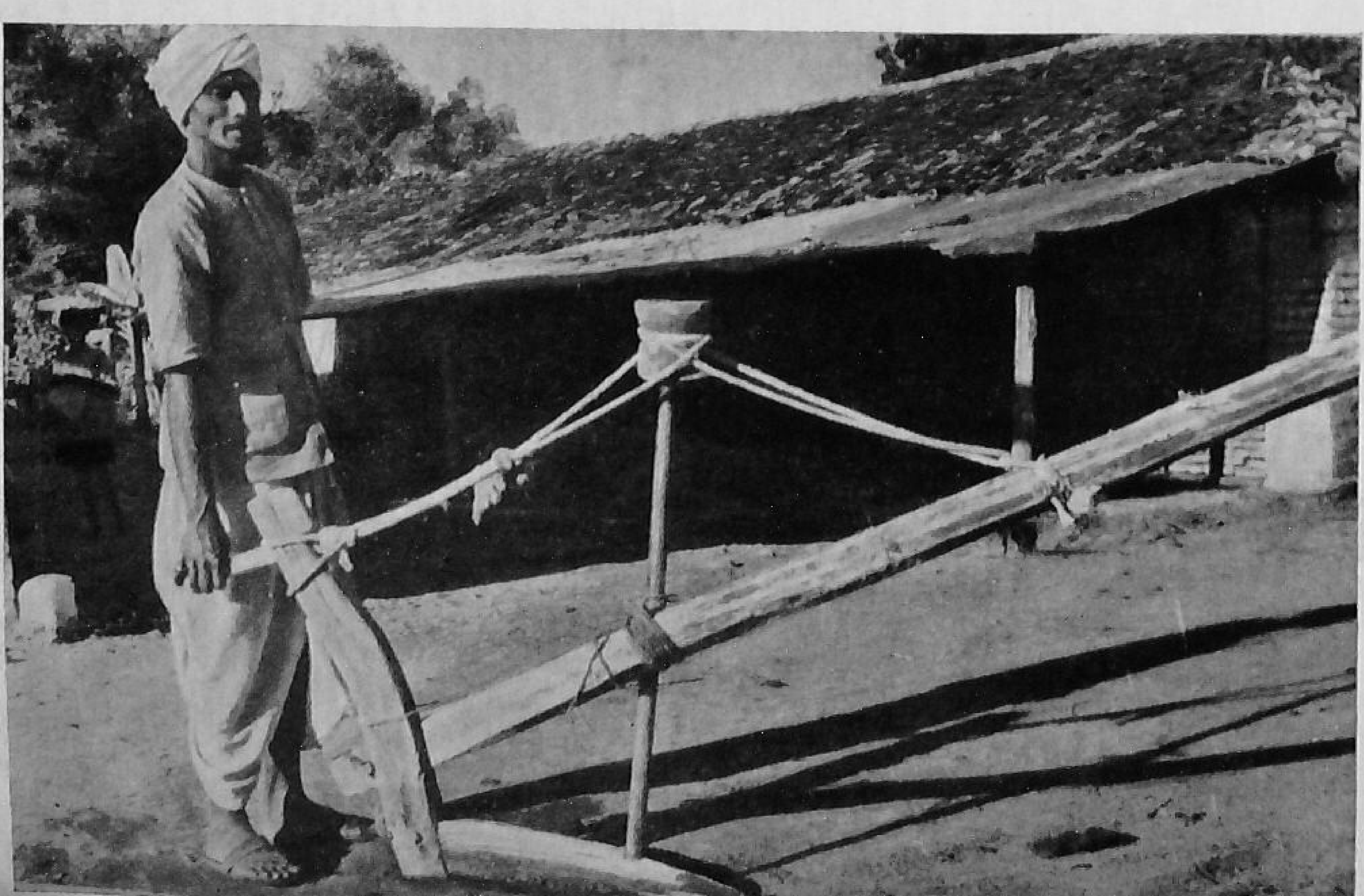


A Buck-scraper

A Green Manure Trampler

A Dufan

A Nari Plough



CROWDER: A crowder is used for making small cross bunds across the slope for soil conservation. Before using a crowder the land should be first ploughed or harrowed. The crowder has two strong clamps. Through their use the inner and the outer mouths of the crowder can be varied in size. The soil is collected at the wider end and is passed through the narrow end, forming a small bund.

BUND FORMERS: Bund formers are an improvement over crowders, as they have handles and beams. They are manufactured in sizes of $2\frac{1}{2}'$, $3\frac{1}{2}'$ and $5'$. A bund is formed by the two collecting mould-boards. The mould-boards can be raised or lowered by means of holes provided on them and the tines, thus increasing or decreasing the collection of soil. The land should be ploughed properly before using this implement, so that enough loose soil is available for collection. Bunds formed by this implement are 8″ to 1′ in height.

CLOD-CRUSHING ROLLERS: Clod-crushing rollers are of various types such as star-shaped, solid or with bars. A seat and a weight box are provided on the frame which holds the rollers.

GREEN MANURE TRAMPLERS: Green manure tramplers have been designed by the Department of Agriculture, Madras. One type has cross plates fixed all round the three holding discs. The axle rotates in bearings. A handle, a beam and a plate to stand on, are also provided if desired. These tramplers are worked with a pair of bullocks. Their capacity is two and half to three acres a day. These are useful for burying green manure crops such as sannhemp.

WETLAND PUDDLERS: Wetland puddlers have been designed after a Burmese implement called 'Satoon.' The bladed star-shaped rollers of this implement rotate in the soil, producing a churning action and mixing the soil with water. Their capacity is one acre per day and they cost about Rs. 85 each. One good pair of bullocks is required to work this implement.

CHAPTER 6

SEED-DRILLS

A variety of implements are used on Indian farms for sowing seed. The commonest is the *nari* plough. This is an ordinary plough fitted with a tube and a seed-bowl. The seed is dropped in this bowl and is conveyed through the tube to the furrow formed by the share of the plough.

A similar type of seed-drill with two tines is known as *dufan*. It has a single seed-bowl with two holes connected with two tubes.

The indigenous implement by means of which three lines can be sown at a time is known as *tifan*. Its bowl has three holes ingeniously made so that when the seed is dropped in the bowl, it gets fairly equally distributed to the three tubes attached to the three holes. The share points of a *tifan* are reinforced with steel blades. An ordinary *tifan* costs about Rs. 25.

A light *tifan* is called *tusari tifan* and is used for sowing *kharif* crops like *jowar*, *bajra* and maize which are not sown deep.

A heavy *tifan* is used for sowing *rabi* crops. It sows to a depth of 2″ to 3½″. The tines are fixed with steel shares. The cost of a *tifan* of this kind comes to Rs. 35.

When the seed to be sown is of a large size, it cannot be sown by a *tifan*. It is then sown with the help of separate tubes called *sartas* which are tied to each tine of an implement called *argada*. The cost of this implement is about Rs. 15.

MECHANICAL SEED-DRILLS: Mechanical seed-drills are machines which automatically drop seed in lines. In the indigenous seed-drills seed has to be dropped by hand in the bowls, while in the mechanical seed-drills seed feeding is automatic. In foreign countries, small broadcasting machines have been designed but the majority of Indian farmers sow seeds

in lines by indigenous seed-drills. Hence, seed broadcasting machines have never been popular in this country.

In the field of designing suitable seed-drills, progress has been rather slow in India. Suitable bullock-drawn models are not available. The weight and the price of foreign seed-drills have hampered their introduction. Another important factor hindering the introduction of these implements is the custom of growing mixed crops like cotton, *jowar*, *arhar* and groundnut on the same piece of land in alternate lines. This type of mixed cropping is practised by small farmers, and it is almost impossible to design a seed-drill that will sow these diverse crops at the same time.

For big farms and estates, however, mechanical seed-drills are now available. In these, use is made of either (a) external forced feed, (b) internal forced feed or (c) spoon feed, for distributing the seed. In the external forced feed mechanism the wheel which distributes the seed has notches on the outside while in the internal forced feed mechanism the notches are on the inside of the wheel. The external forced feed mechanism is more popular in India.

The internal forced feed type of seed-drill is very useful for crops like wheat.

The spoon feed type of seed-drill has circular discs, on the periphery of which small spoons are fixed which pick up the seed. Four or five different-sized spoons are provided in order to increase or decrease the seed-rate and to sow seed of different sizes. The spoon feed type seed dropping mechanism is used in the Walker seed-drill.

In these machines power is transmitted to the seed distributing wheel by means of gears attached to the ground wheel. The dropping of seed is thus automatically regulated by the speed of the wheel. If the bullocks walk slowly, less seed is dropped; if the bullocks walk quickly, more seed is dropped. Thus, a fairly constant seed-rate is maintained. The seed is placed in a seed-box and it is picked by cups or notches and dropped in a funnel to be transmitted by tubes to the tines and thence to the furrows.

The external forced feed mechanism is used in the seed-

drills manufactured at Allahabad and Lucknow and in the seed-drill manufactured by McCormick International Ltd. The approximate price of the McCormick seed-drill is Rs. 1,280 for a seven tined model. Double disc furrow openers are used in this drill.

Planter type seed-drills are used when a more accurate spacing between the plants is required. In such seed-drills, horizontal discs with holes are used in the seed-boxes. These are more suitable for crops like cotton and maize. A trigger arrangement is provided to force the seed into the funnel.

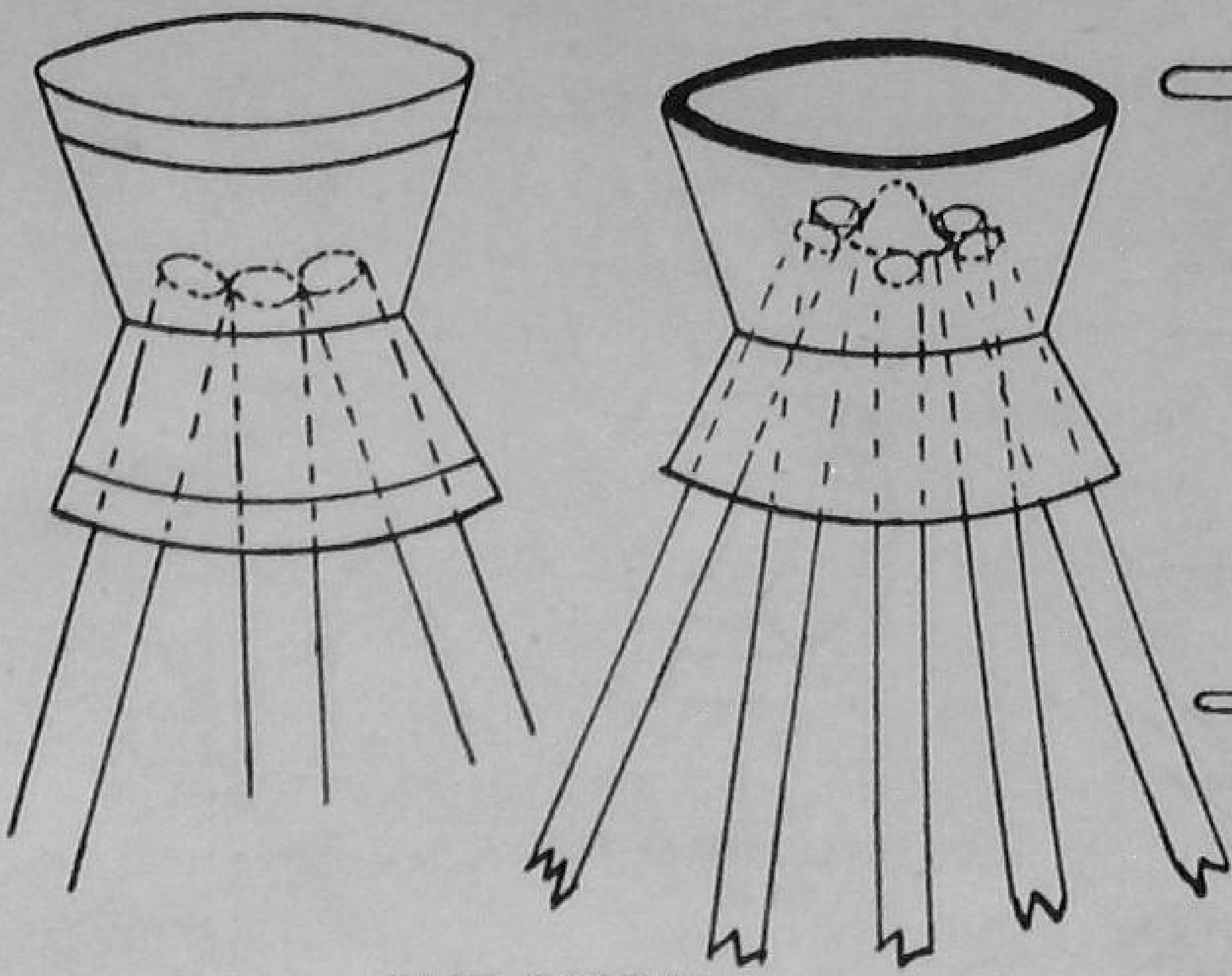
A grain-drill developed by the Department of Agriculture, Madras, incorporates a horizontal disc with holes for dropping seeds. Power is transmitted from the ground wheels by means of a tight 'V' belt. The distance between the tines can be changed. Seed is stored in a round tin box, in which the disc is horizontally placed. The drill is suitable for sowing millets, wheat, gram, etc.

Another drill has been developed in the Punjab in which two seed-boxes are used. Seed from the upper seed-box is picked by discs fixed in the lower seed-box before it is dropped in funnels. These discs have notches on their periphery. Wooden wheels are used in this drill.

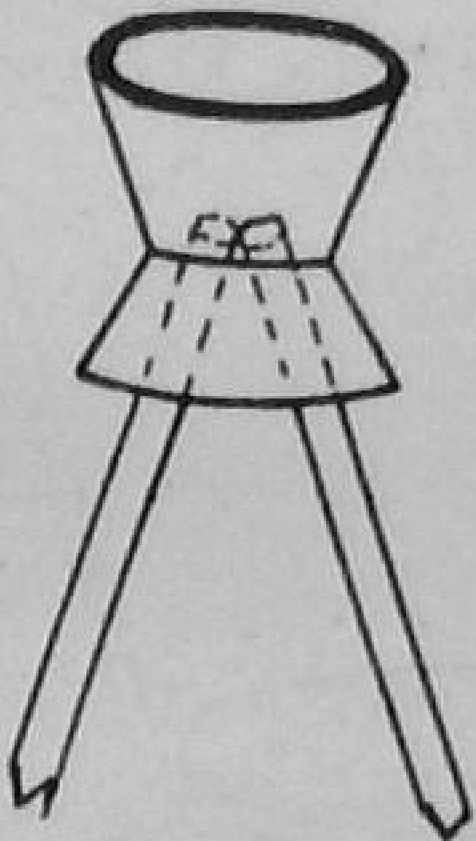
Various types of furrow openers like the shoe type, the hoe or share type and the disc type are employed in a seed-drill.

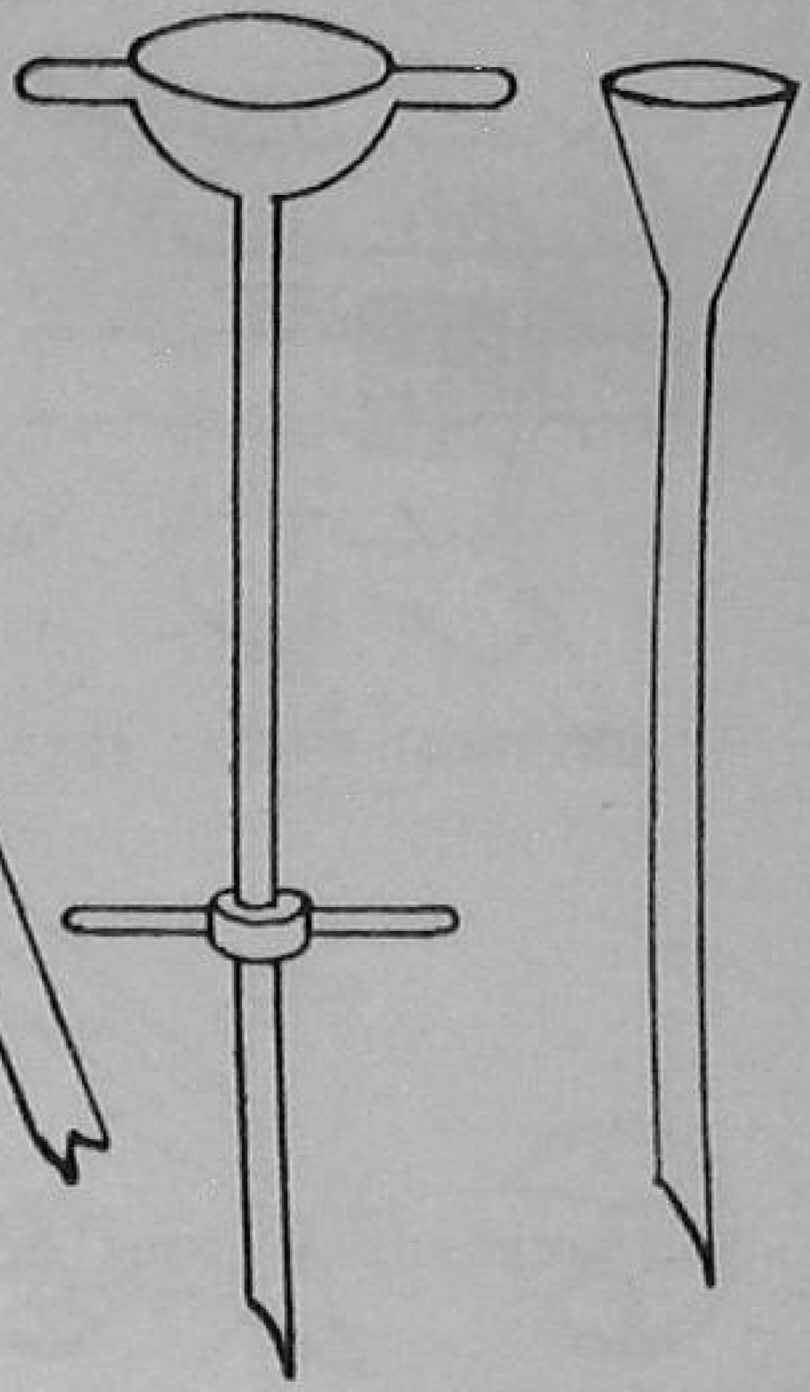
An ideal seed-drill should have:

1. A dependable seed-dropping mechanism by means of which seed can be dropped uniformly. The mechanism should be such that it can be used for seed of various sizes.
2. Devices to adjust the seed-rate, the distance between the furrows and their depth.
3. An arrangement for covering the seed after it is dropped in the furrows.
4. An arrangement so that it can turn easily at the end of a furrow.
5. Arrangements to disengage the seeding mechanism where necessary, so that the seed is not dropped even if the ground wheels move.

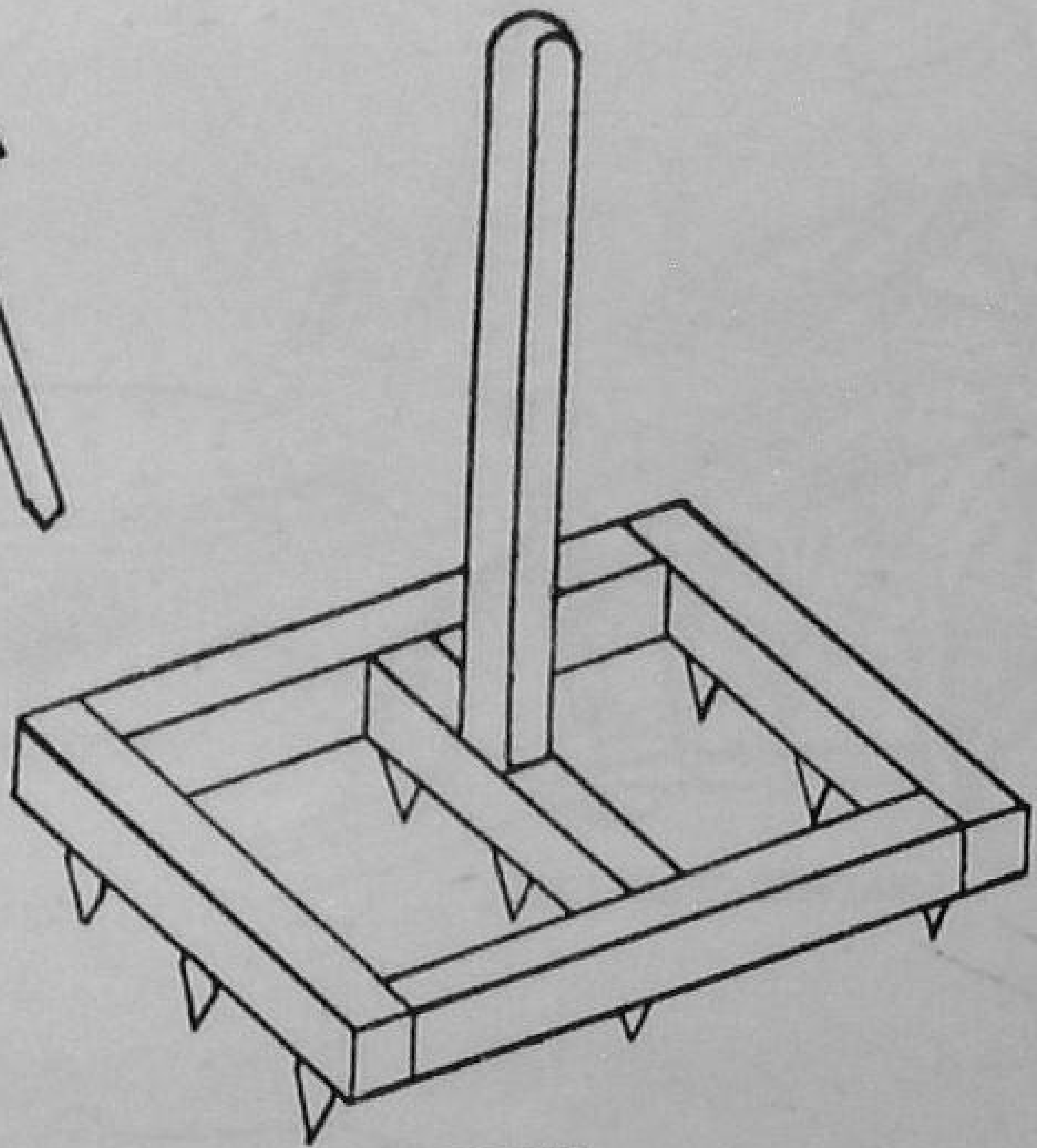


SEED BOWLS

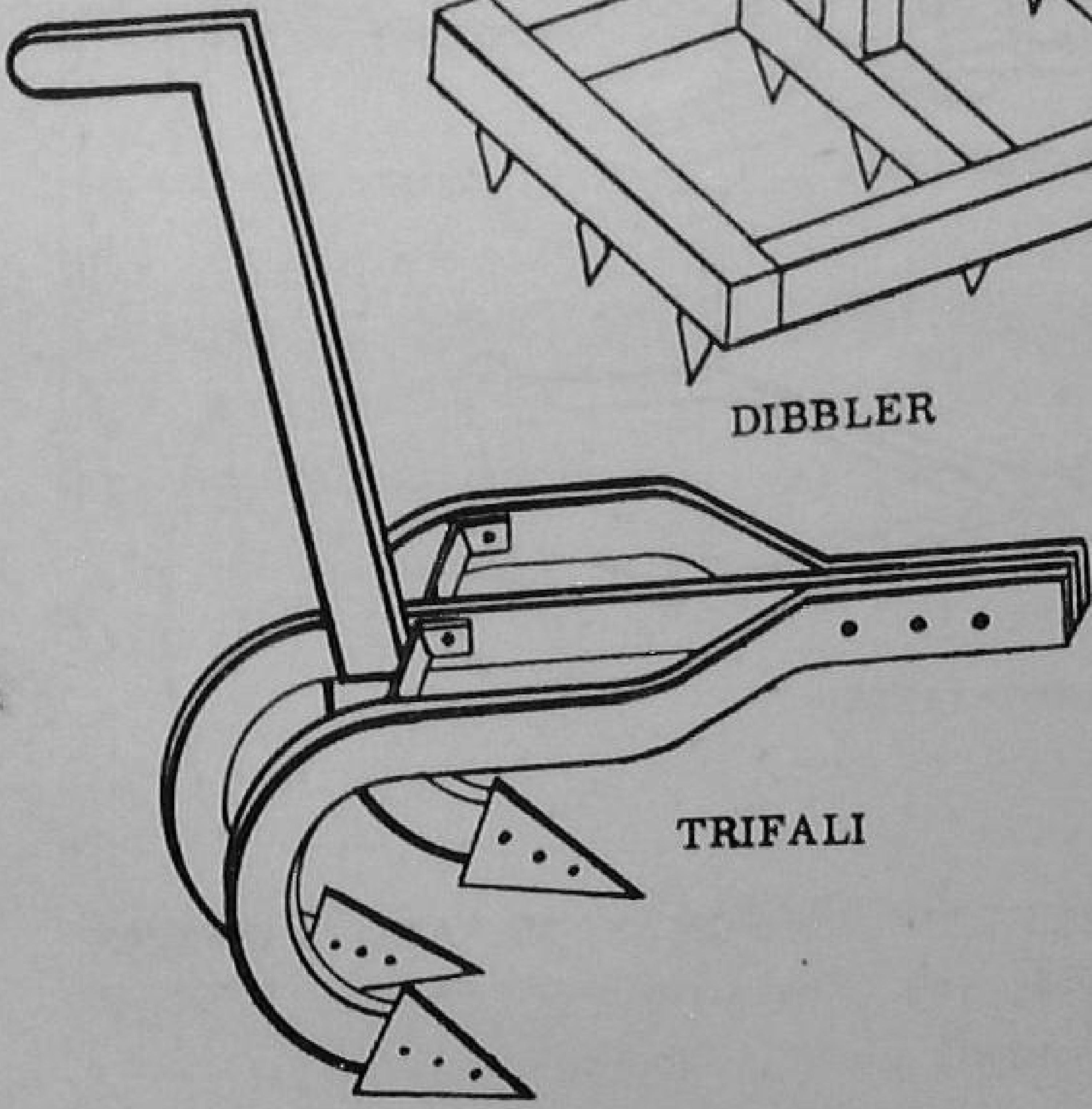




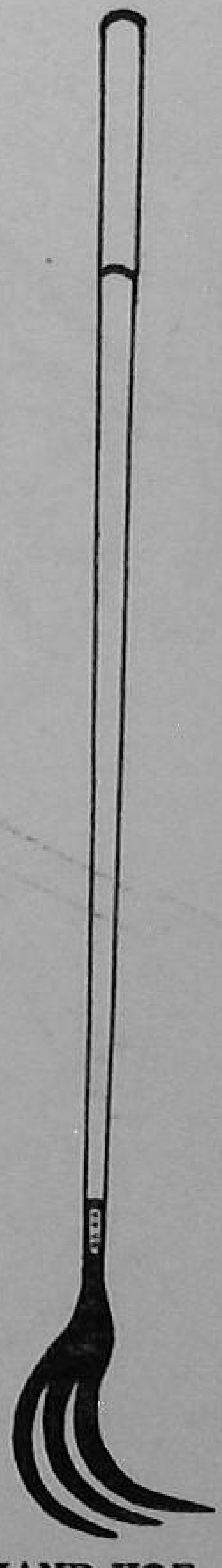
SARTAS



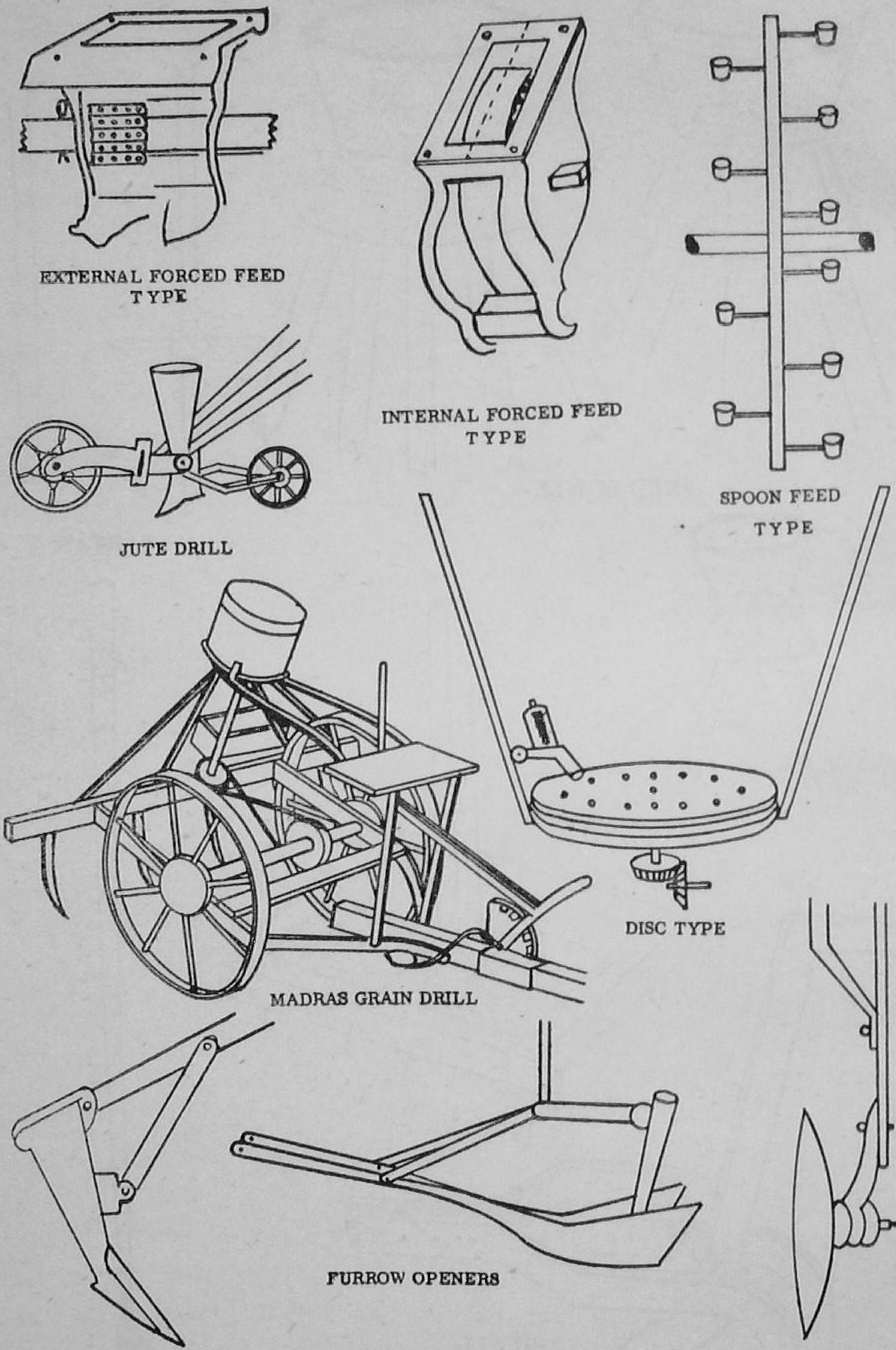
DIBBLER



TRIFALI

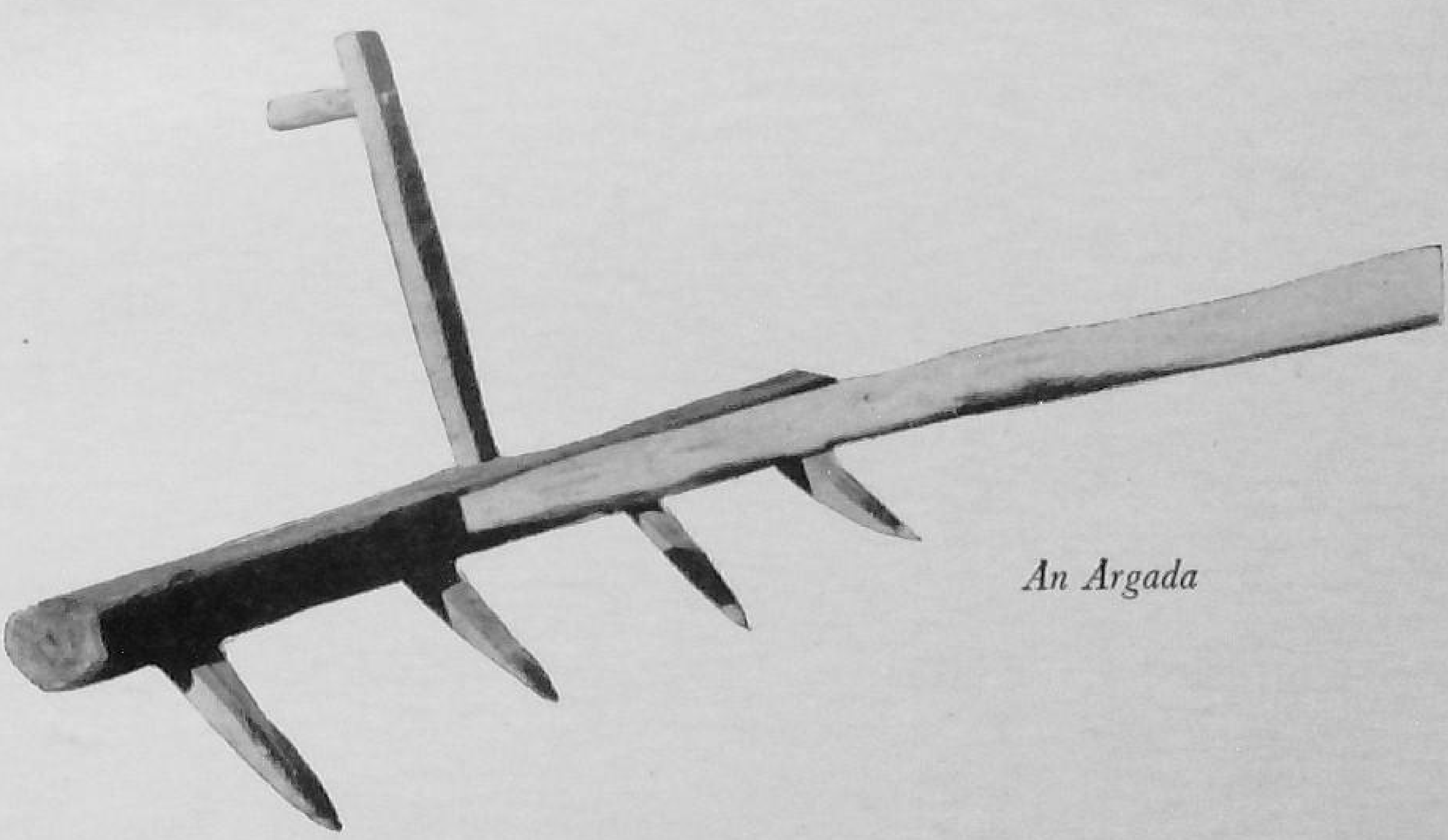


HAND HOE



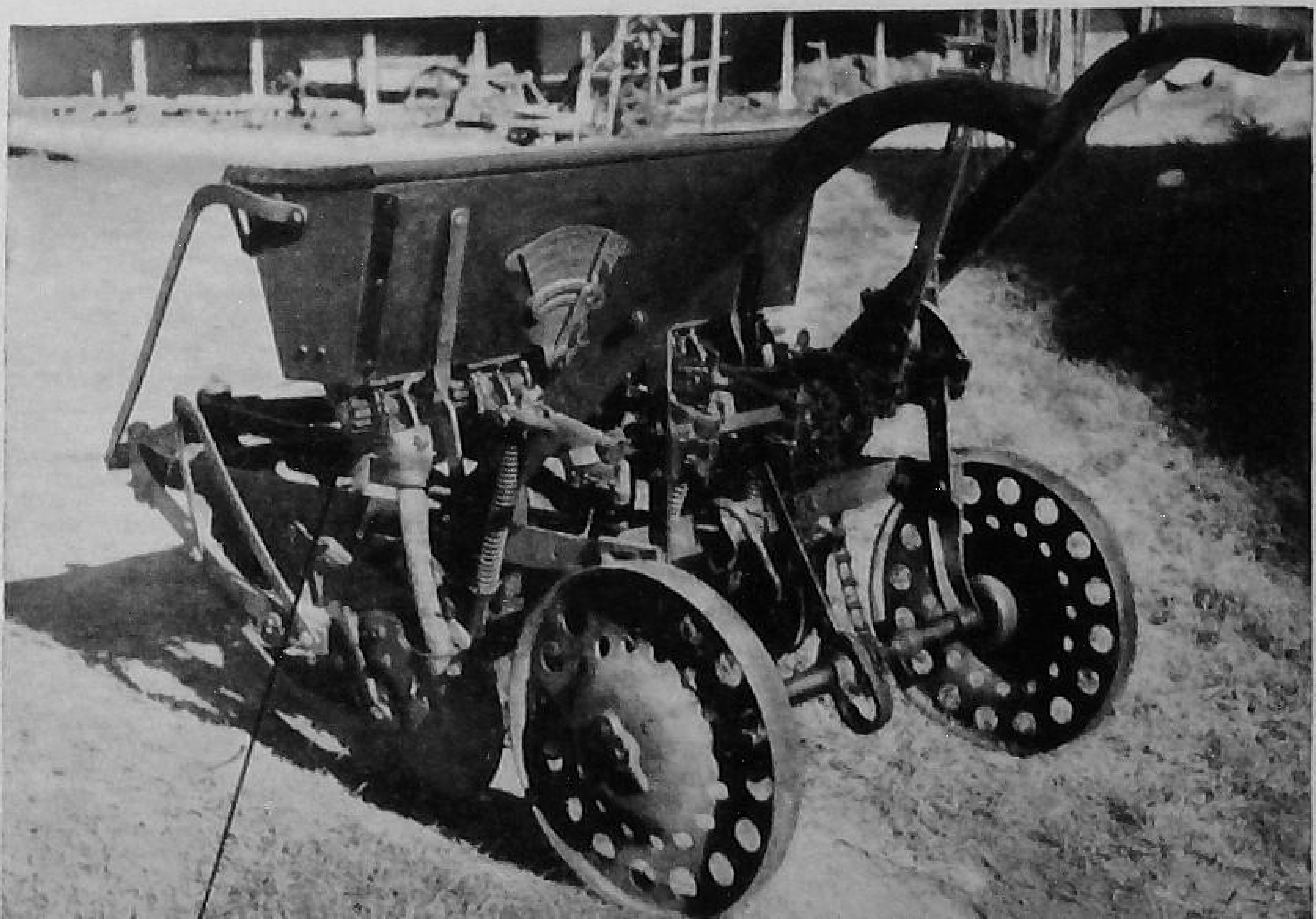
Types of Seed-distributing Mechanisms and Furrow Openers in Seed-drills

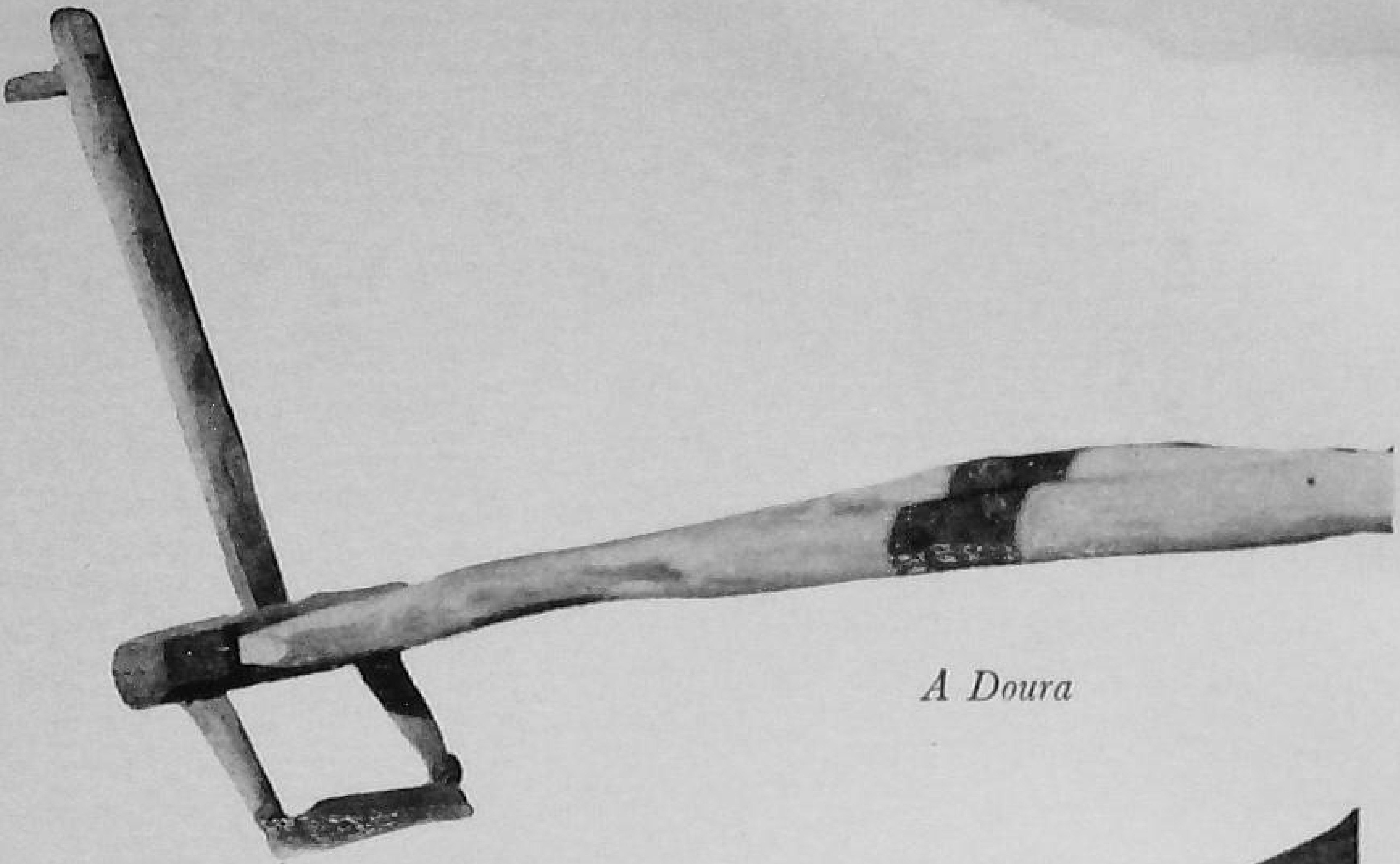
A Tifan



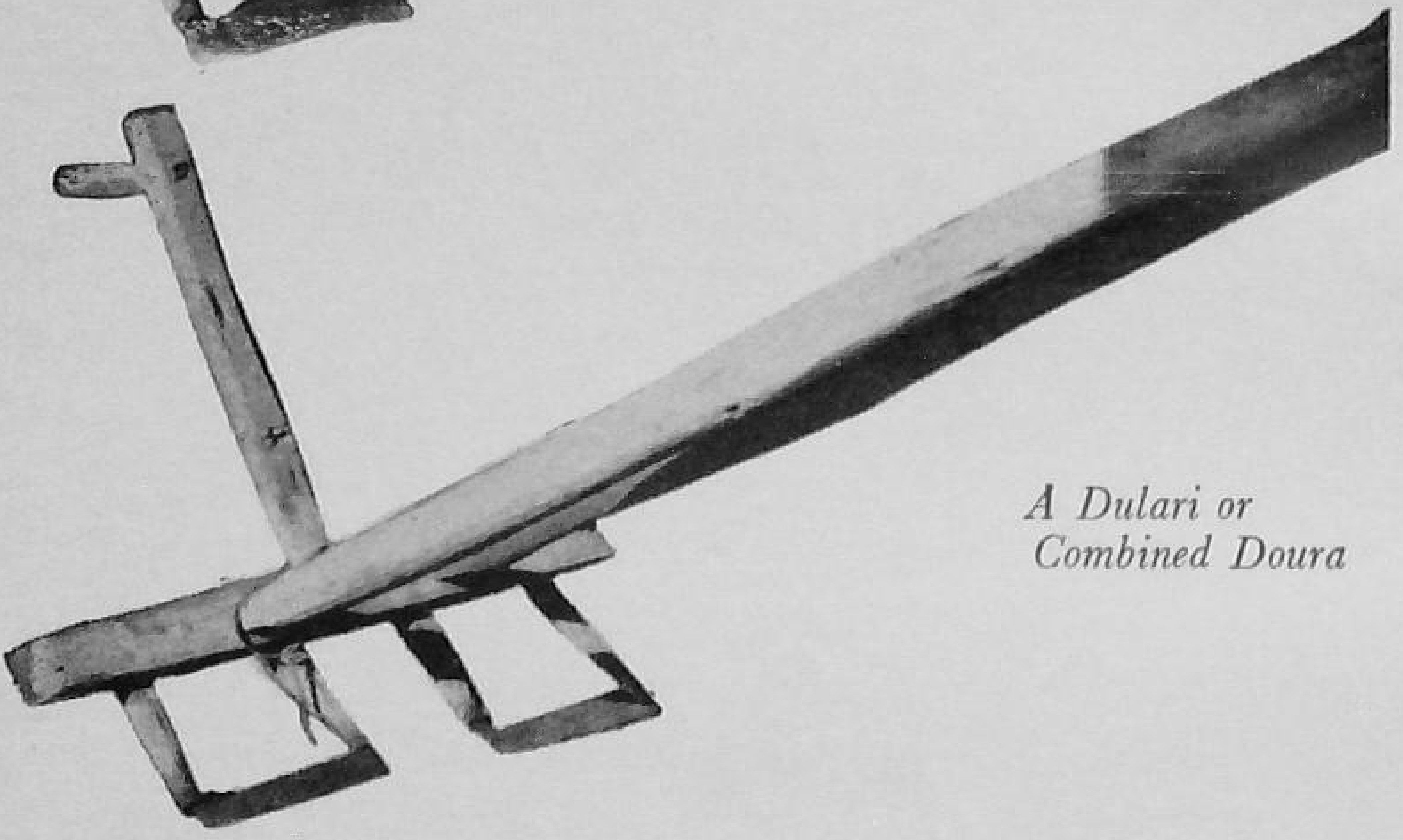
An Argada

A Mechanical Seed-drill with External Forced Feed Mechanism



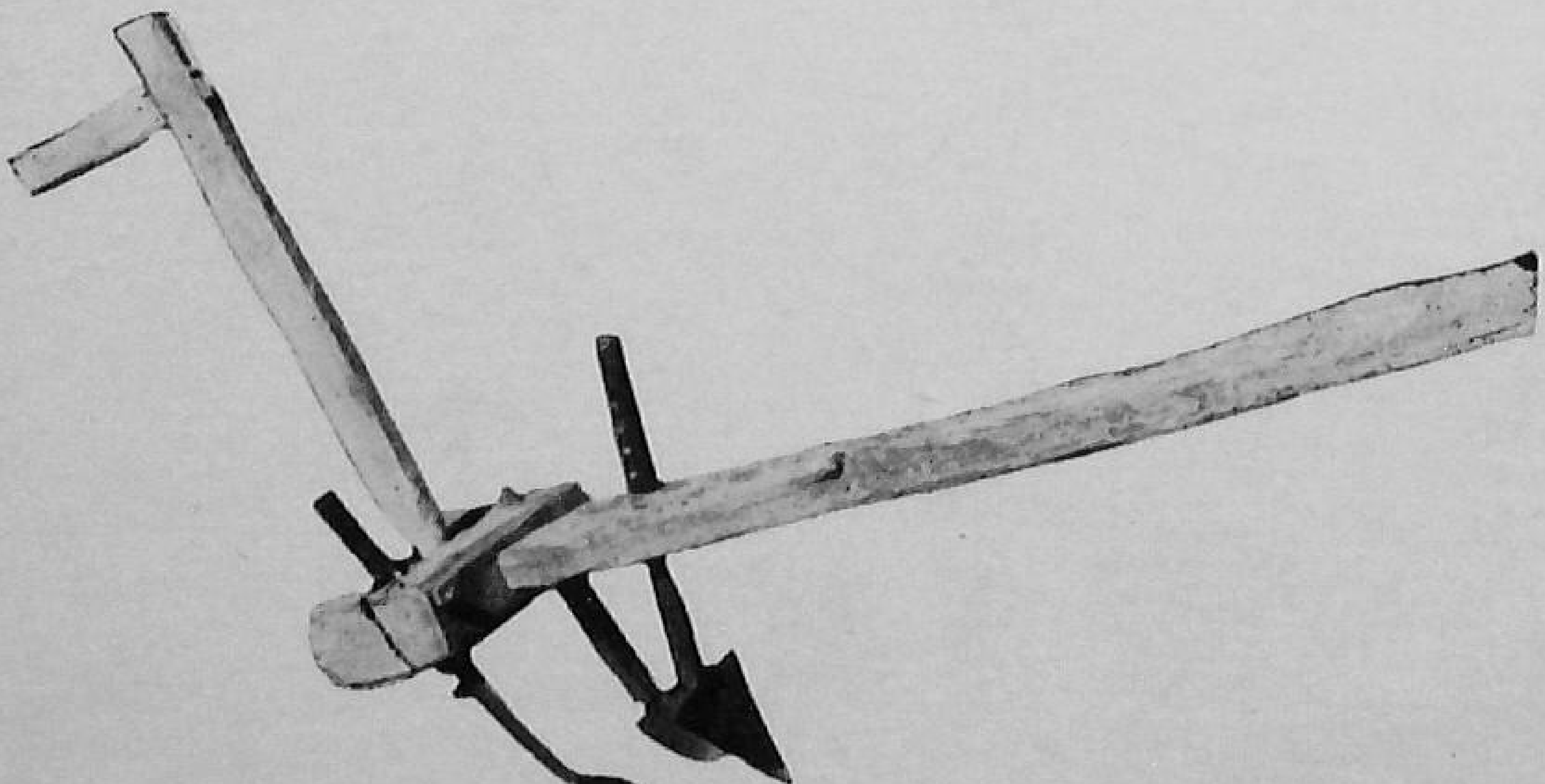


A Doura



A Dulari or
Combined Doura

The Indore Ridger



The Akola Hoe

6. A seed-box of sufficient capacity so that it is not necessary to fill it often.
7. Durable power transmission and other parts.
8. An arrangement to sow seeds and fertilizers at the same time if necessary.

For garden crops, special types of seed-drills are available. A Japanese model has a wooden roller with small depressions, which is placed in the seed-box to carry the seed outside. In this machine, power is transmitted by a link arrangement from the roller in the front.

For sowing jute, a special seed-drill costing Rs. 80 has been designed in West Bengal. A roller with depressions is used in this drill.

Modern seed-drills have not yet become popular in India. Much work remains to be done in introducing useful seed-drills to our farmers. The nature and magnitude of it can perhaps be judged from the fact that in the U.S.A. and Australia tractor driven seed-drills normally cover 25 to 40 acres a day. In Italy and Russia automatic transplanting machines have been designed, and in the U.S.A., seed has been experimentally broadcast by aeroplanes covering nearly two lakh acres in ten hours.

Chapter 7

INTERCULTIVATION IMPLEMENTS

Wherever line sowing is practised, intercultivation between rows of plants becomes essential to kill weeds, to earth up the plants and to prepare soil mulch. For this purpose, various types of bullock-drawn or manually operated implements known as hoes are available.

In the Deccan plateau and in Madras, line sowing by indigenous implements has been in vogue for centuries. Here, farmers use hoes known as *douras* for intercultivation. Two or three such implements are yoked to a pair of bullocks and are worked in-between rows of plants. Each implement requires a separate man to guide it. These *douras* are actually miniature *bakhars* or *guntakas*, with blades ranging from 6″ to 12″ in width.

Where plants are small and it is possible to work over them, a combined *doura* called *dulari* is used. This can only be worked as long as the plants have not formed hard wood. It costs Rs. 10.

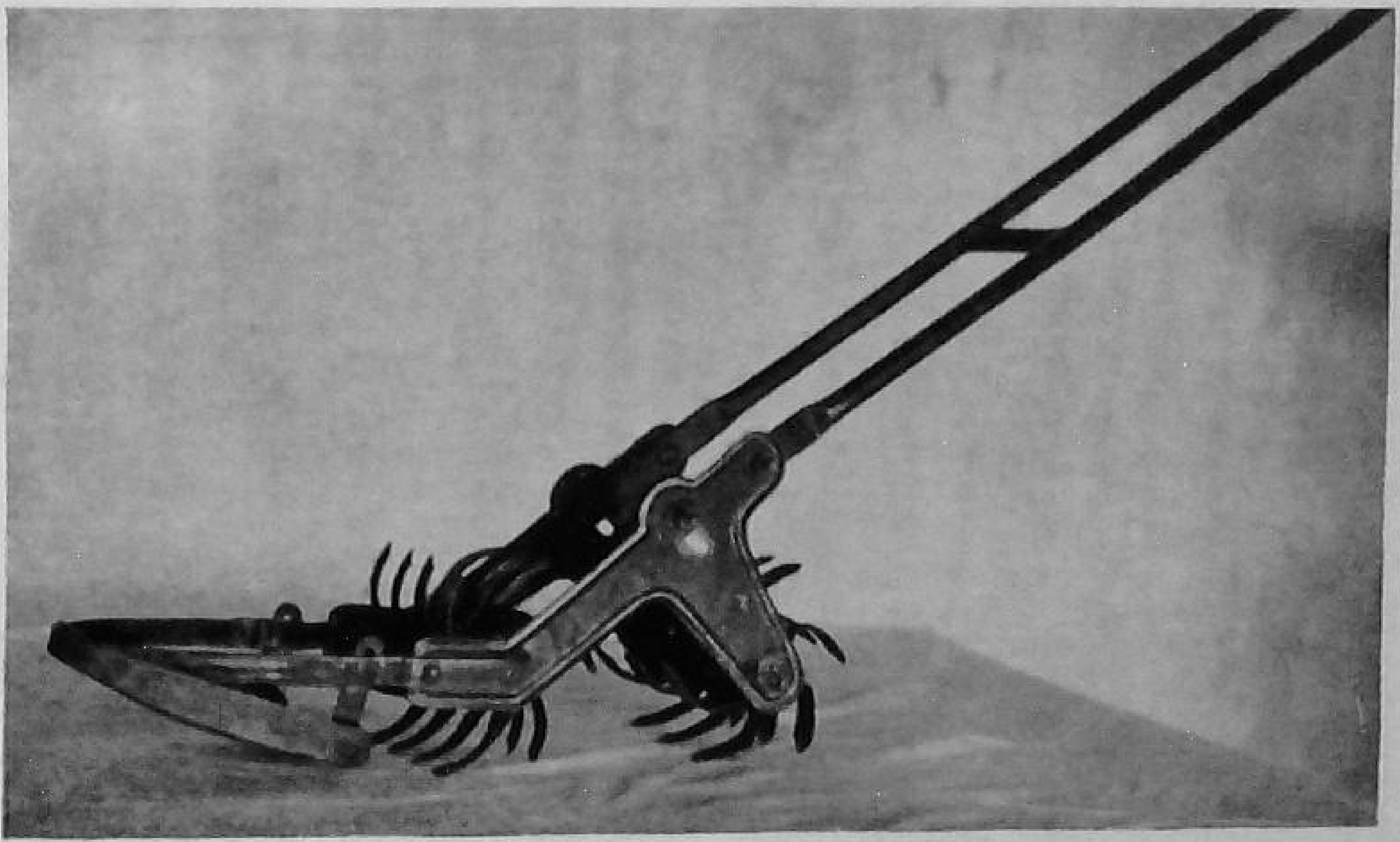
In the black cotton soils, these bladed implements do not work well. A decade back, experiments were conducted at the Government farm, Akola, and a three tined implement, the Akola hoe, was evolved which has become popular in the cotton growing tracts of Bombay. It has sharp triangular steel shares fixed on tines. These penetrate the hard soil easily. A pair of Akola hoes costs about Rs. 30.

An improved type of Akola hoe, developed at Baroda, is called the Baroda hoe. In this, the body on which the tines are fixed is made from iron plates and holes are provided to make the distance between the tines adjustable.

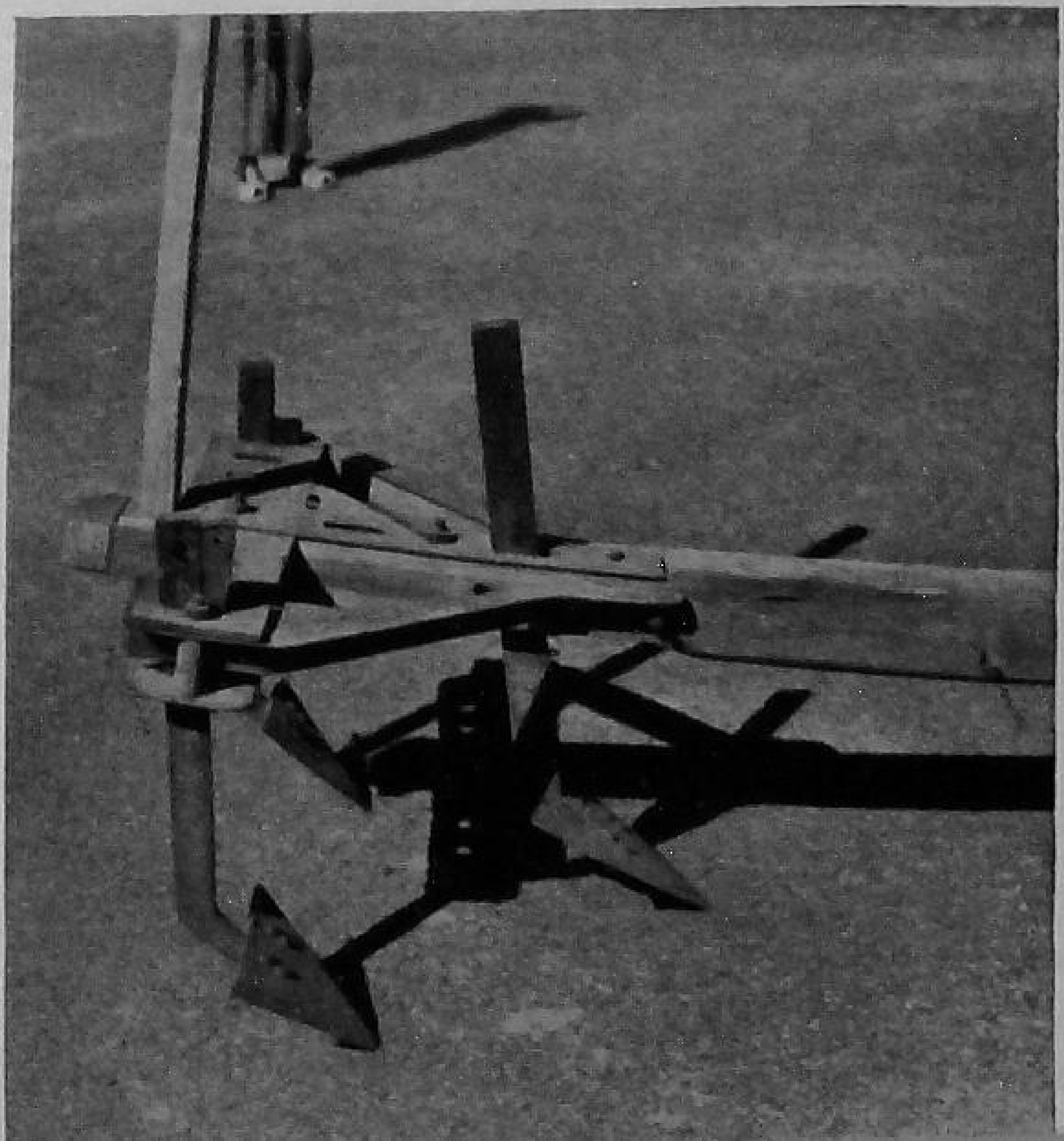
A simpler version of the Akola hoe is used in the Punjab and is locally known as *trifali*.

The single-wheel hand hoe is useful for vegetable cultivation and for flower gardening. It may have additional attach-

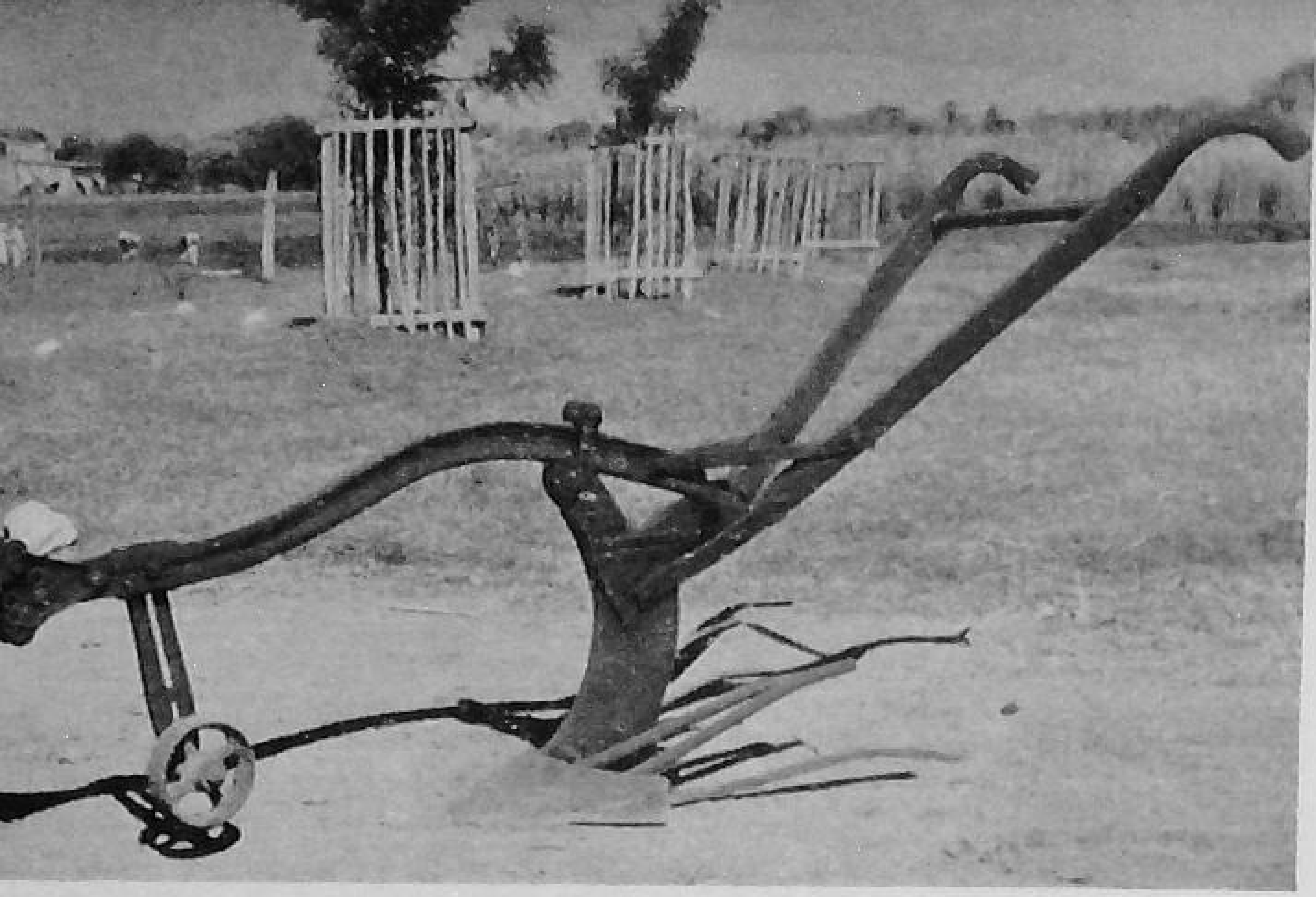
A Single-wheel Hand Hoe



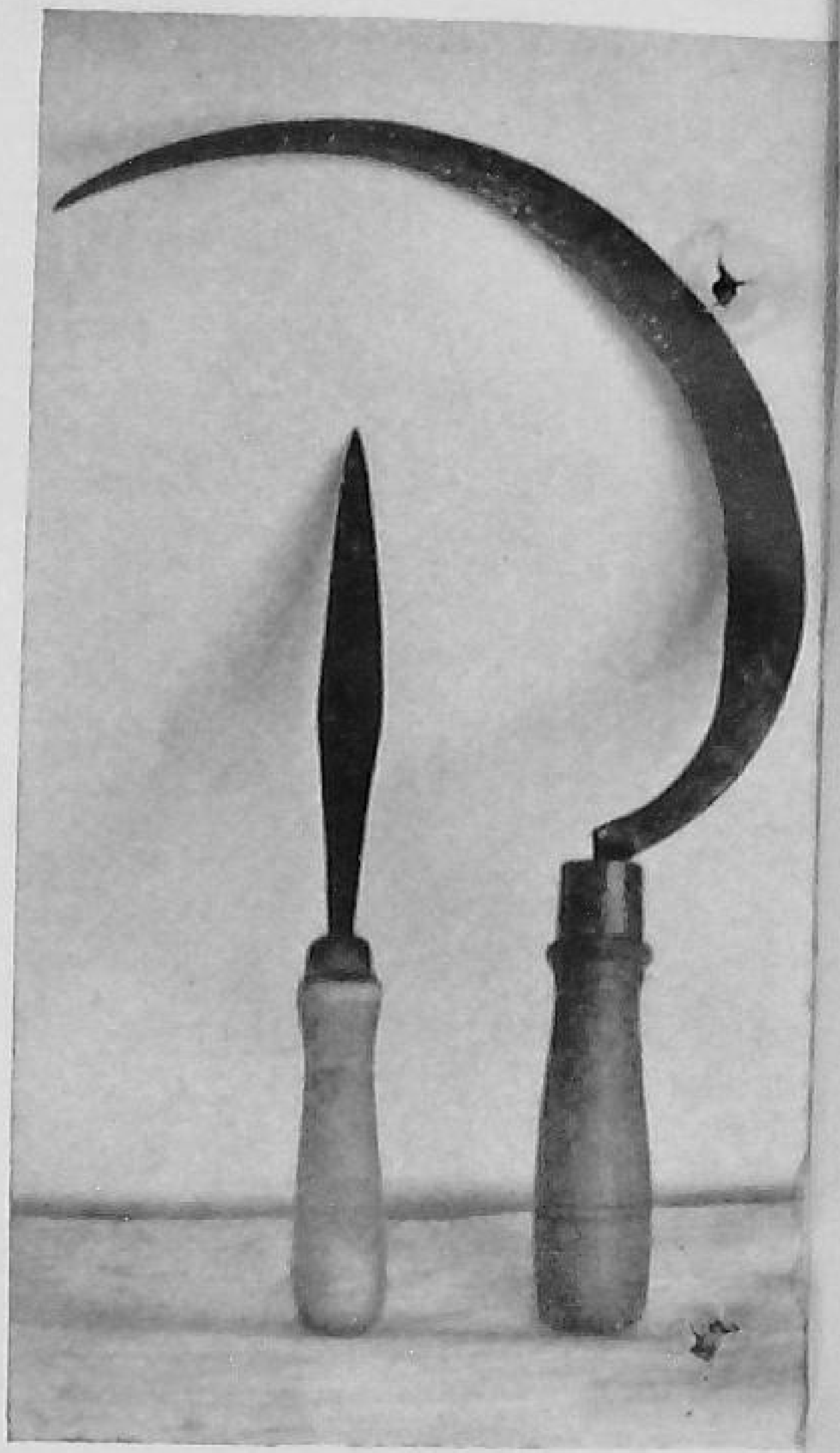
A Japanese Paddy Weeder



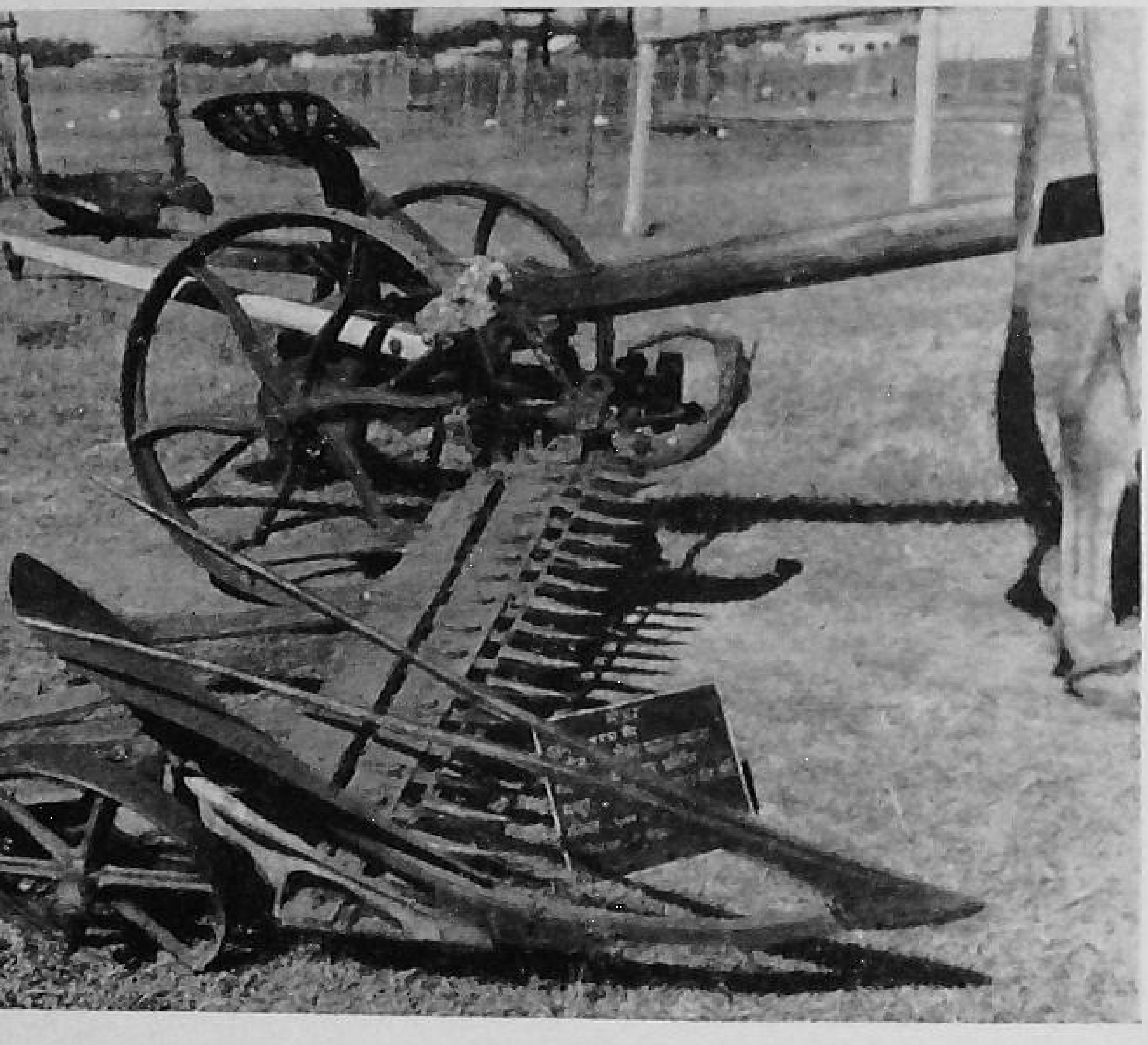
The Baroda Hoe



A Potato Harvesting Plough



A Sickle (right) and a Sharpening File



McCormic Mower

An Olpod Thresher

ments such as steel cultivator-teeth or a garden plough. It is easy to handle. It scrapes the soil, prepares soil mulch and kills weeds. Its price ranges from Rs. 25 to 45.

Since the introduction of the Japanese method of paddy cultivation into India on a large scale, the Japanese paddy weeder has become indispensable for intercultivation of wet-land paddy.

The machine buries weeds, churns the soil and earths up plants. It consists of two rotary pronged rollers fixed on a frame to which a float is attached in the front and a handle at the back. The correct way to use the weeder is to move it to and fro between rows of paddy plants. It can cover one half to one acre per day. The swinging metallic float in the front prevents the weeder from bogging down in mud. The prongs or teeth on the roller should point towards the handle for better work. The weeds are buried in the soil and killed by suffocation. This important difference distinguishes the Japanese weeder from other hoes used in dryland farming which uproot the weeds and leave them on the surface of the soil. This weeder is a great labour saving device. A double weeder, in which four rollers are fixed on one implement, is also available. It requires two persons to work it. However, it cannot be worked when plants have grown sufficiently high.

CHAPTER 8

HARVESTING EQUIPMENT AND THRESHING MACHINES

The Indian farmer usually uses only a sickle for harvesting his crop. For him it is a multipurpose instrument. In Western countries, however, for different crops, different harvesting machines are used, like wheat harvesting combines, potato harvesters and sugarcane harvesters. Harvesting has become a specialised job in the Western countries because of the large tracts under the same crop, the high cost of labour, and the capital and the mechanical talent available. In India, it is not possible to make use of these big machines because firstly, the capital to purchase them is not available, secondly, the technicians to repair these machines are not there and thirdly, big farms where these machines can be used are very few.

SICKLES: Various types of sickles are used for harvesting in India. They can be classified as follows.

1. The curved sickle used in the Deccan
2. The sickle used in the Punjab
3. The sickle used in Uttar Pradesh
4. The improved type of sickle with serrated edges which can be sharpened by means of a file

The cost of these sickles ranges from 50 naye paise to Rs. 1.50 each. In the Punjab sickle, the handle is so attached that the crop can be cut right from the bottom without hurting the knuckles of the hand. The U.P. sickle has a long handle for cutting crops like sugarcane. In the Deccan sickle, both the edges are sharpened.

Some of the finest sickles in the world are those manufactured by the Japanese. These are made from three layers of thin steel. The middle layer is the hardest and the layers on both sides are soft with the result that the sickle becomes self-sharpening.

POTATO HARVESTING PLOUGH: Potato is a very common

crop in many parts of the country, particularly in Himachal Pradesh and the southern parts of Madhya Pradesh.

Potatoes are usually harvested by working the *desi* plough and then picking them up by hand. When the soil becomes very hard, it is not possible to work the *desi* plough. As a result, a good portion of the crop remains inside the soil. In order to avoid this loss, a potato plough which can penetrate hard soils and which can separate soil from potatoes by means of the steel files attached to it, is used. The cost of the implement is about Rs. 80.

Machines for Harvesting Cereals: Machines for harvesting crops like wheat and *jowar* are now available in India and can be worked purely by bullock power or a combination of bullock and engine power. In the latter case, the bullock power is used only to pull the machine and an auxiliary engine is used for providing power to move the cutting knife at a considerable speed. The McCormick International bullock mower costs about Rs. 300 and is suitable for farms of over fifty acres. As harvesting is usually a race against time, weather and insect attack, it is necessary that this operation should be performed at the earliest possible time after the crop is ready. Particularly in recent years, it has been observed that when the crop is ready for harvesting, unexpected hail storms cause great loss to the farmers.

The McCormick mower can be used with advantage by a group of farmers on a cooperative basis. In this mower, power is transmitted from the ground wheels to the cutting blade by means of a pair of internal spur gears and a pair of bevel gears and an eccentric wheel which transforms the circular motion into the to and fro motion of the knife. The knife moves to and fro between the fingers in which it is held. The fingers lift the crop. The teeth on the knife are so adjusted that they cut the crop from both the sides when the knife moves forward and backward.

A platform is provided on which the cut crop falls, from where it is collected and tied into sheaves. The ground wheels have cleats which grip the soil. Along with the machine, a knife grinder to sharpen the knife is also supplied.

The gear-box of the machine should be properly oiled. The level of the cutting knife should also be correctly adjusted as soon as the machine is taken to the field.

An auxiliary engine to move the cutting knife should be fitted on the mower when strong bullocks are not available and when the crop is heavy and dry. The engine reduces the draught on the bullocks considerably. The mower with the engine can be used for cutting crops like wheat, paddy, *jowar*, *bajra*, etc. One man can harvest four to eight acres in ten hours with the help of the engine. The engine is worked on petrol or paraffin.

Threshing Machines

After harvesting, the next agricultural operation is of threshing the crop. For threshing, three implements are generally used. They are the threshing roller, the Olpod thresher, and the combined thresher-winnower.

The threshing roller is made of stone or concrete and is 3′ in length and has a diameter of 1½′. It is used only in the southern districts of Bombay.

The Olpod thresher is probably the most popular threshing machine in India. It consists of a series of plain or notched discs placed on two or three axles which are fixed on an angle iron frame on which an operator's seat is provided. At the back, an expanded metal guard is attached so that there is no danger of the operator getting injured. The cost of a good quality machine of this type is Rs. 300 to 400. A pair of bullocks and two men can thresh with it economically. The cost works out to only 75 naye paise for threshing 1,000 lb. of wheat with the machine, while for threshing the same quantity of grain under bullocks' feet the cost works out to Rs. 1.31. Ordinary wheels are also provided on the Olpod thresher to facilitate its transportation.

Japanese Paddy Thresher: The Japanese type paddy thresher is useful for threshing crops like paddy and wheat. The grain is separated from the plant by the impact of the revolving drum on the face of which steel hooks are fixed. The operator works a pedal and the motion is transmitted to the

drum as in a sewing machine. Machines operated by one man or two men are available in India. The machine operated by one man costs Rs. 150. The machine is more suitable for work on experimental farms.

Chapter 9

WINNOWERS

Winnowers are used to obtain an artificial breeze for separating grain from chaff and dust. In order to improve the quality of winnowing, a number of sieves to separate the grain are also provided in some machines.

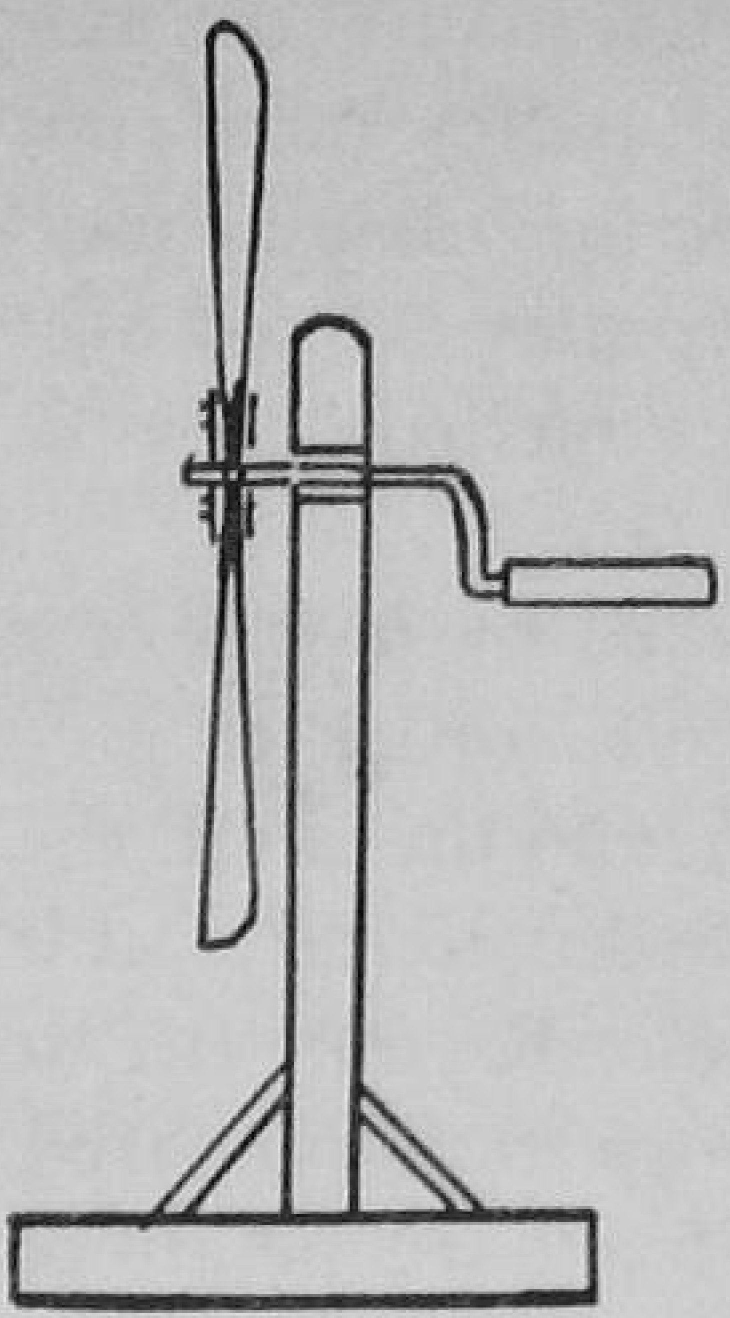
In the months of February, March and April, when the grain is ready for harvesting, it is noticed that either dust storms or hail storms occur. To protect their grain from these natural calamities, farmers are anxious to store their produce soon after harvesting but the operation of winnowing cannot be carried out if there is no natural breeze. Because of this, winnowers have become popular in many areas. If farmers have winnowers, they need not wait for any natural breeze and can winnow quickly, even in a shed.

Various types of winnowers, ranging from a simple fan to a rather complicated machine incorporating a fan, sieves and a vibrating mechanism, are available in the market.

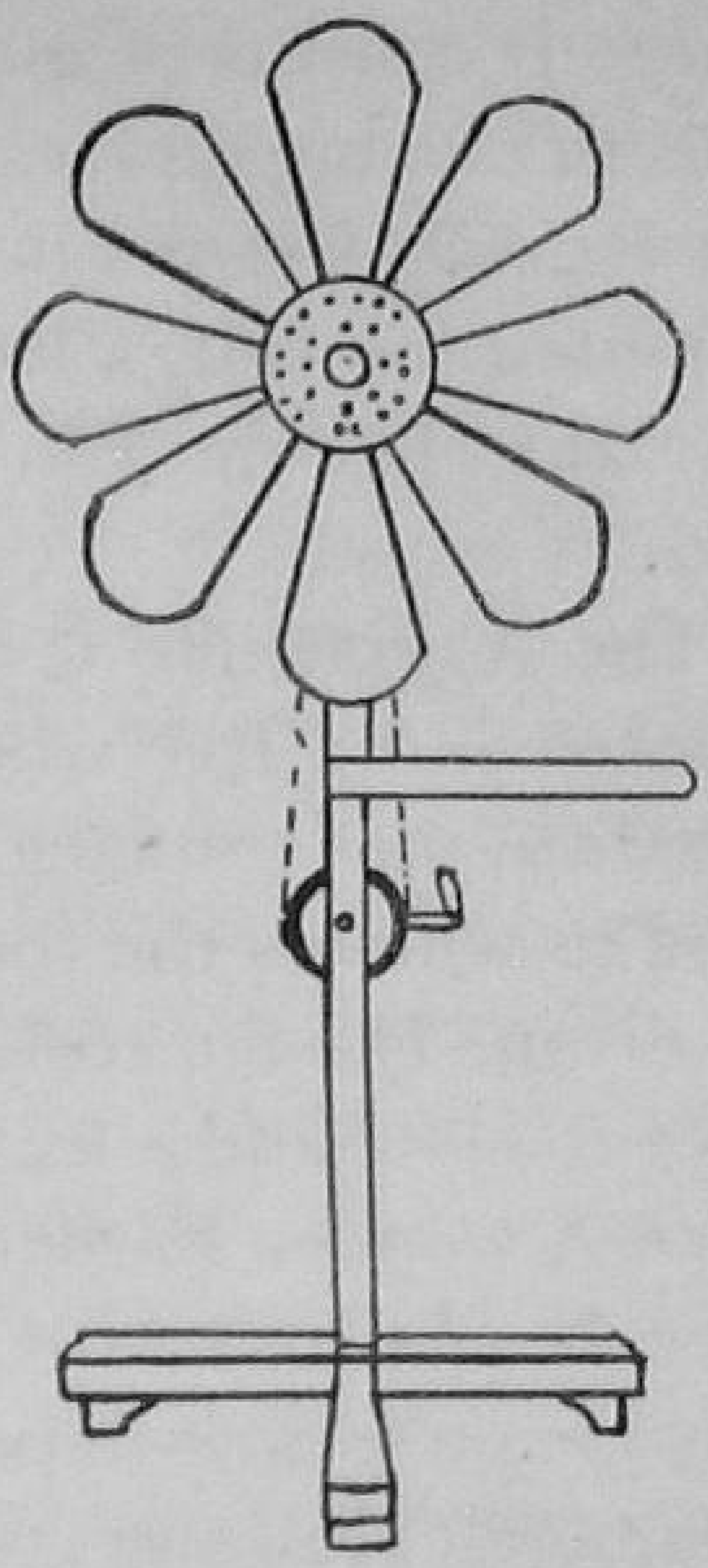
Winnowing Fans

Nilokheri Fan: This fan, designed at the Workshop Wing, Extension Training Centre, Nilokheri, has proved very successful. The fan has no ball-bearings, gears or chains and yet it generates a sufficiently strong breeze to winnow such crops as paddy and *jowar*. The volume of air generated by the fan is so much that two persons can winnow the threshed material at a time. One man can easily drive the fan. The cost of this fan comes to about Rs. 30. It can be manufactured and repaired by a village blacksmith. Its blades can be dismantled after use and it can be stored in a very small space. Its capacity is about 1,300 lb. of chaff and grain per hour.

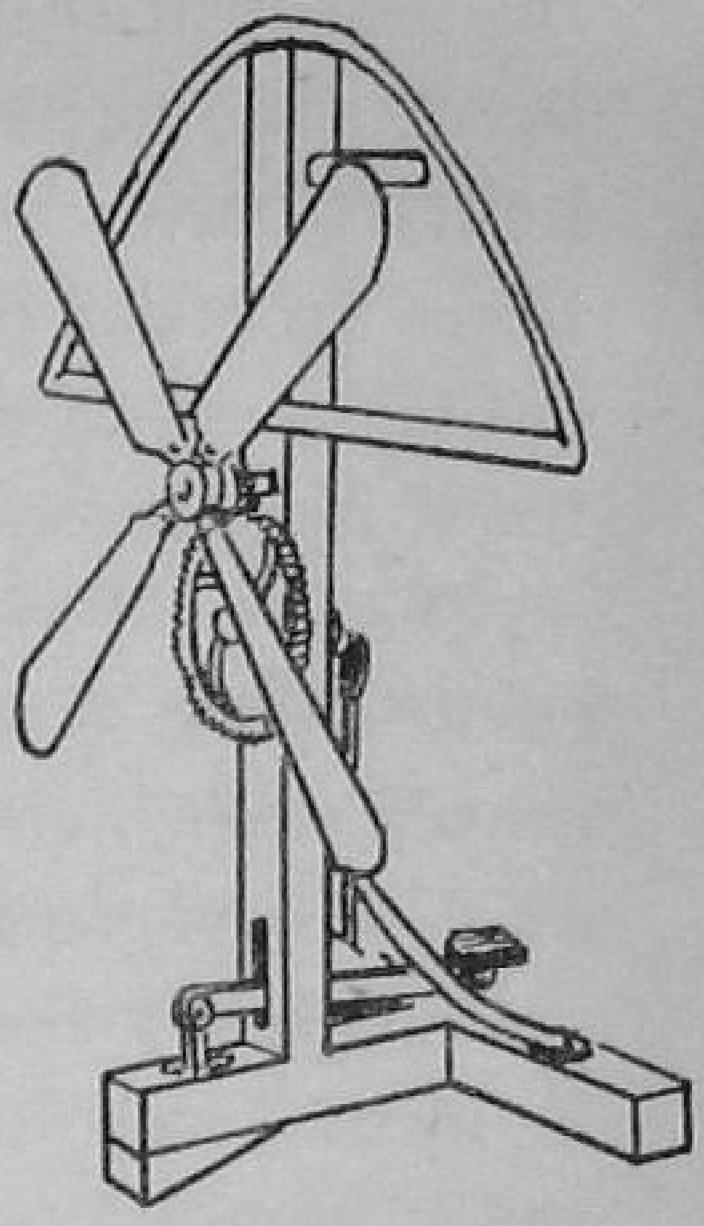
Allahabad Fan: The Allahabad fan was designed by Mr. Mason Vaugh, Agricultural Engineer at the Allahabad



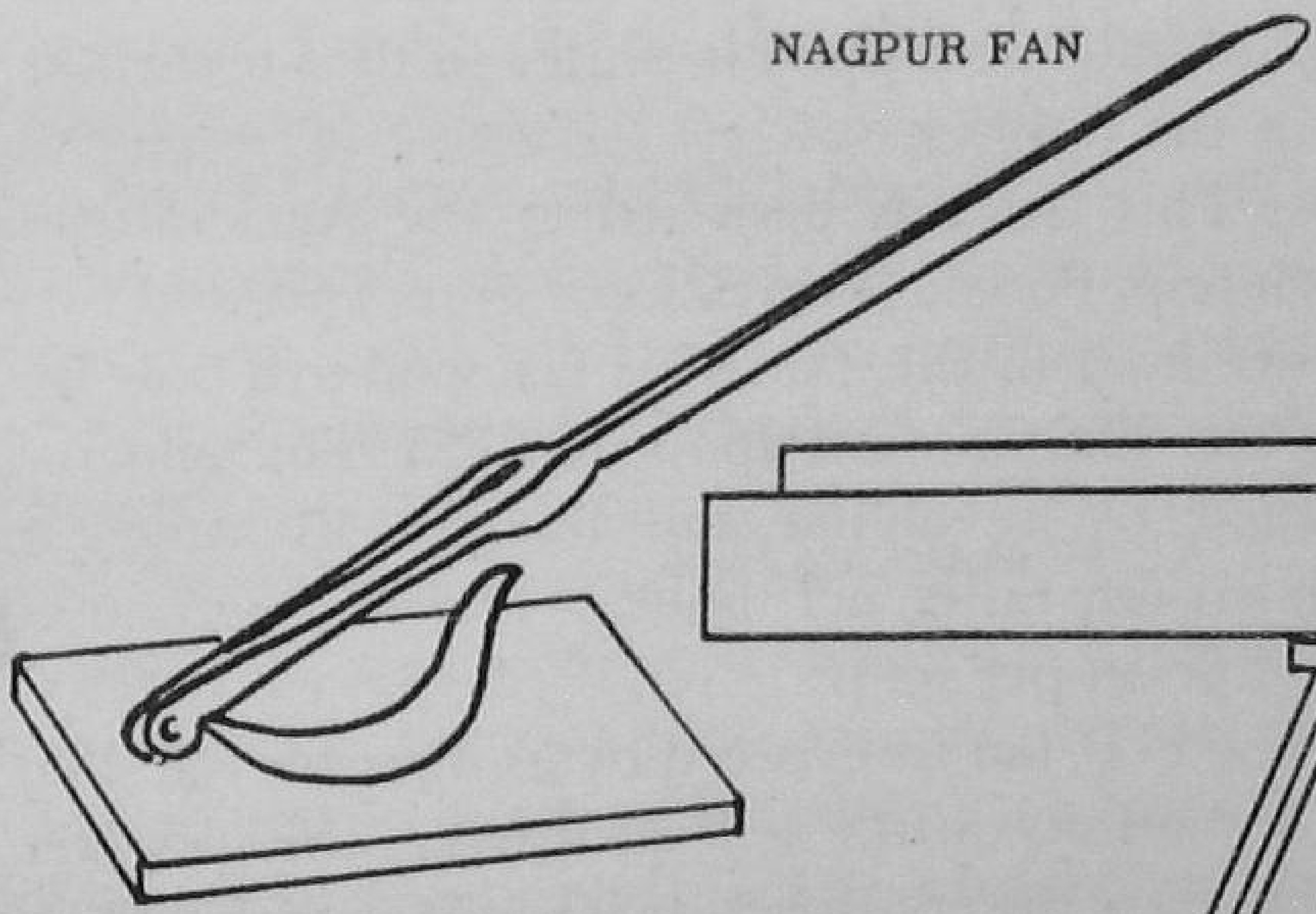
NILOKHERI FAN



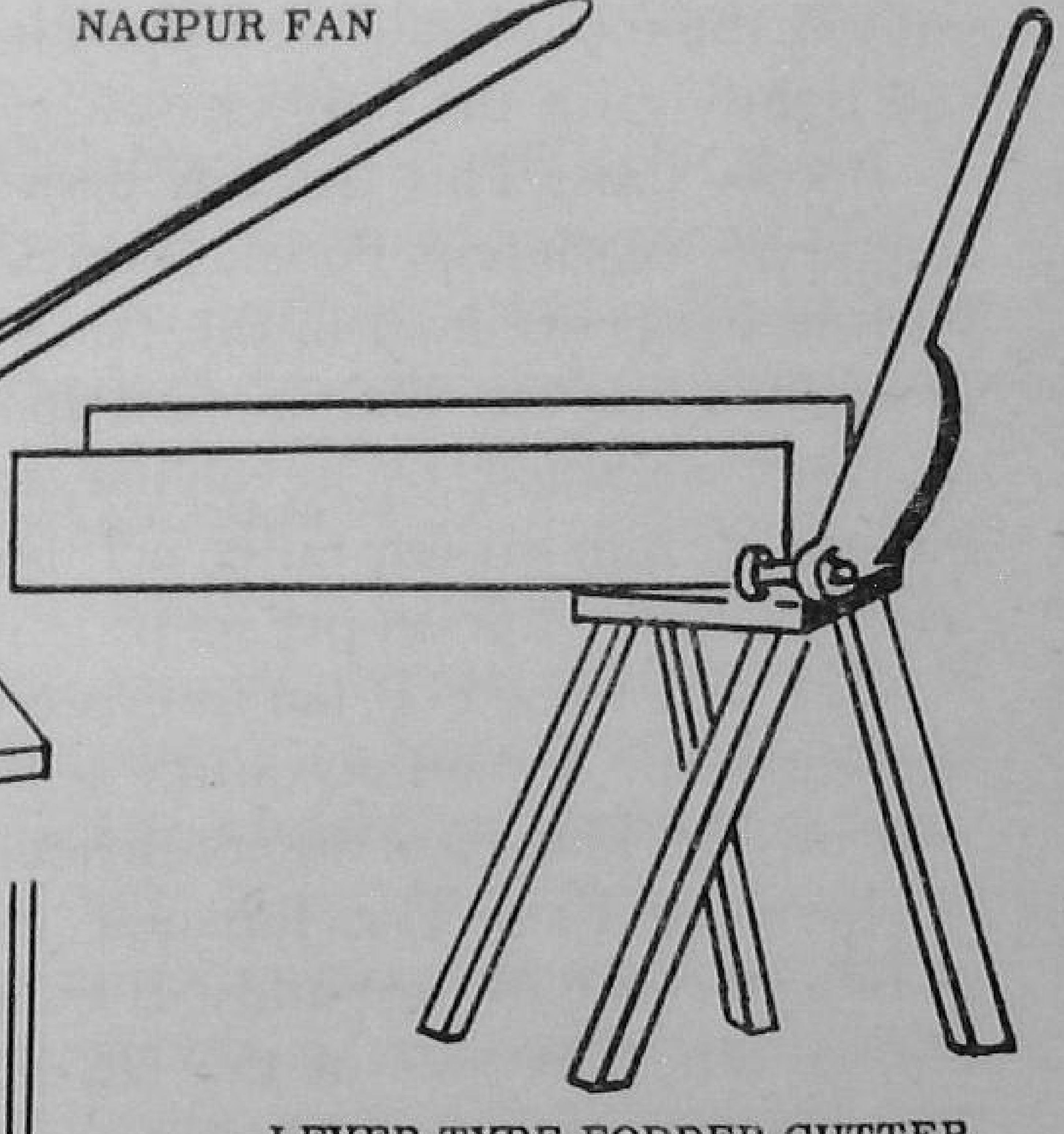
NAGPUR FAN



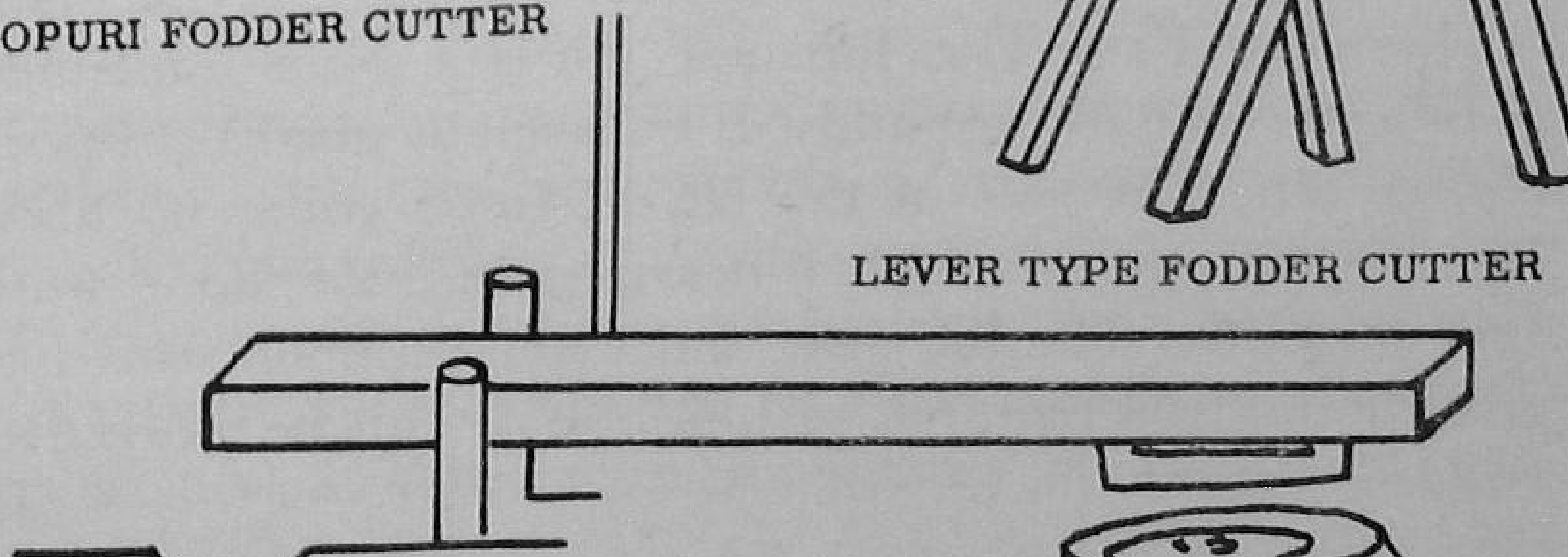
JAPANESE FAN



GOPURI FODDER CUTTER



LEVER TYPE FODDER CUTTER



SEVAGRAM FODDER CUTTER

WINNOWING FANS AND FODDER CUTTERS

Agricultural Institute. It consists of short fan blades, the axle being rotated by means of a big and a small pulley and a rope belt. It costs about Rs. 60, and is suitable for village conditions. In order to tighten the belt, a loose pulley is fixed over it by means of a weight. The fan can be attached to a pole fixed in the ground.

NAGPUR FAN: The Nagpur fan is worked by means of a cycle chain, a sprocket and a free wheel. In order to give ample clearance between the cleaned grain and the chaff, the man who is required to winnow the threshed material stands on a high stool or a drum. The fan costs about Rs. 50. It can be moved from place to place and is fixed on a stand prepared out of wooden *ballies*. A wooden batten is fixed at a height of about 5′ to guard the driver. Instead of the chain, the sprocket and the free wheel, rope pulleys or flat or 'V' pulleys can also be used with advantage. However, while using the rope pulleys, the rope should be dipped in water so that it shrinks and tightly grips the pulleys.

POONA FAN: This fan was designed at the Agricultural Engineer's Workshop, Poona. Two pairs of spur gears and two bush-bearings are used in this fan. It is fastened to a pole by means of a bracket. The fan costs about Rs. 125. The velocity of wind obtained by revolving the handle 40 times a minute is nine to ten miles per hour. The fan winnows nearly 250 lb. of grain per hour.

U.P. FAN: The U.P. fan is revolved by using a bicycle-like arrangement. A man sits on the seat and drives the sprocket with his feet. The rest of the construction is similar to other fans.

JAPANESE FAN: The Japanese fan is a small implement suitable for winnowing paddy. It is driven by means of a pedal mechanism. The cost of the fan in India comes to about Rs. 40. The fan has two ball-bearings and, therefore, works very smoothly. The big gear and a small pinion used in it give the fan the required revolutions. It can be worked by hand or by feet.

Winnowing Machines

Steel winnowers are manufactured out of sheet metal of

24 to 26 gauge and are commonly used on government farms and large estates. They are quite sturdy and durable and give good service for a number of years.

The machine consists of a shell in which a four-bladed horizontal winnowing fan is fixed on two ball-bearings. A small pinion which meshes with a big gear having a handle is attached at the end of the axle of the fan. When this fan is rotated, wind is driven towards a group of sieves which are suspended at the other end of the winnower. The draught of the fan can be regulated by two sliding shutters. By means of a simple link mechanism the sieves rock automatically. This link mechanism consists of an eccentric wheel which gets its rotation from the axle of the winnowing fan. The eccentric wheel is connected to the suspended portion of the sieves by means of a long L-shaped sheet rod and a triangular steel link. When the fan is worked, power is automatically transmitted to the sieves and they get the required rocking and jolting.

A steel winnower costs about Rs. 450 to 550. A set of about six sieves is supplied along with each machine. These sieves may have two, three, four or 12 holes to an inch. The overall dimensions of a standard machine are 6′-9″ length, 5′ width and 4′-9″ height. There are 88 teeth on the main gear and 22 on the pinion. These gears should preferably be machine cut for smooth operation. The nuts and bolts used in a winnowing machine should have split pins in them so that they do not get loosened by vibrations. In good winnowers, a fly-wheel is also provided. The winnowing fan shaft should have pedestals for the ball-bearings.

Generally, five labourers are required to operate a steel winnower. It can also be worked by a one horse power engine or an electric motor by reducing their revolutions to 180 per minute.

Small winnowers, suitable for farmers having 60 to 100 acres of land and similar in construction and operation, are also available.

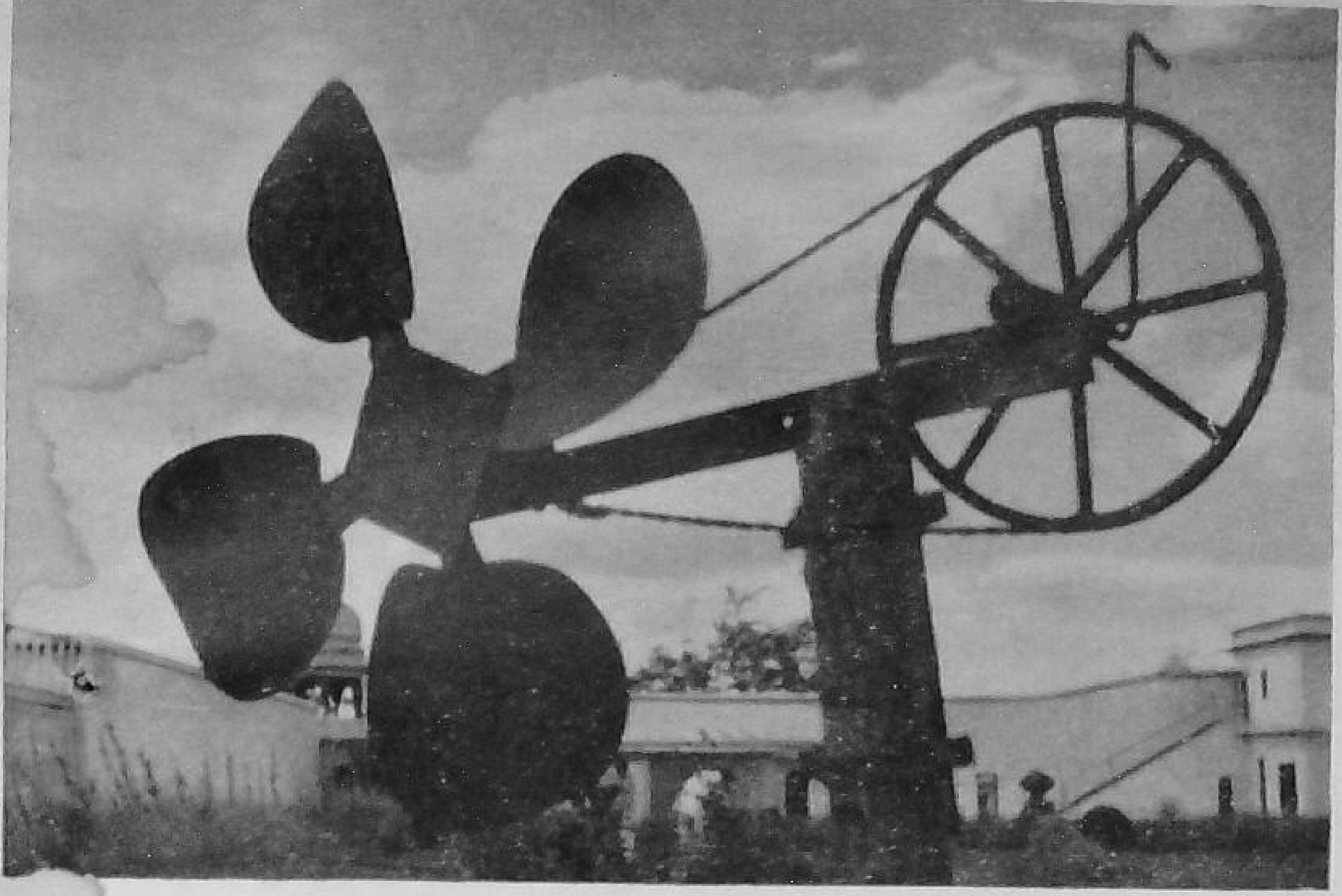
Wooden winnowers are less costly than the steel ones. They can winnow approximately 3,000 to 5,000 lb. grain per

hour. They cost about Rs. 250 to 300. Most of the mechanisms incorporated in the steel winnowers are included in them.

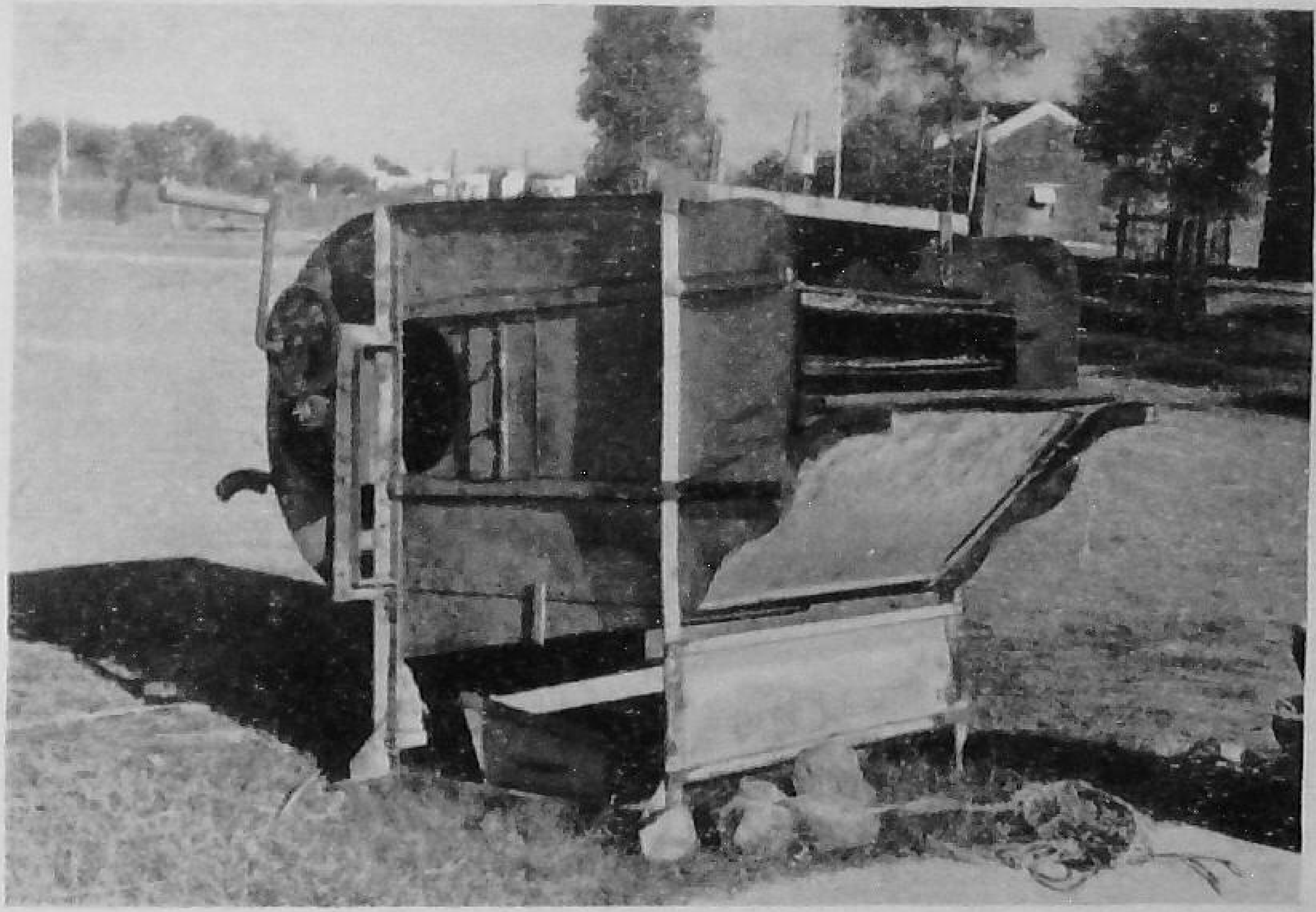
These winnowers can be used for crops like *jowar*, wheat, paddy, gram and *arhar*. Each of them can winnow about 1,000 lb. of *jowar*, 5,000 lb. of paddy, 400 lb. of wheat, 200 lb. of linseed and 6,000 lb. of gram per hour. When one has to winnow *arhar* and soyabean, it is necessary to repeat the operation three times before clean grain is obtained.

The following precautions should be taken while operating winnowing fans or winnowers.

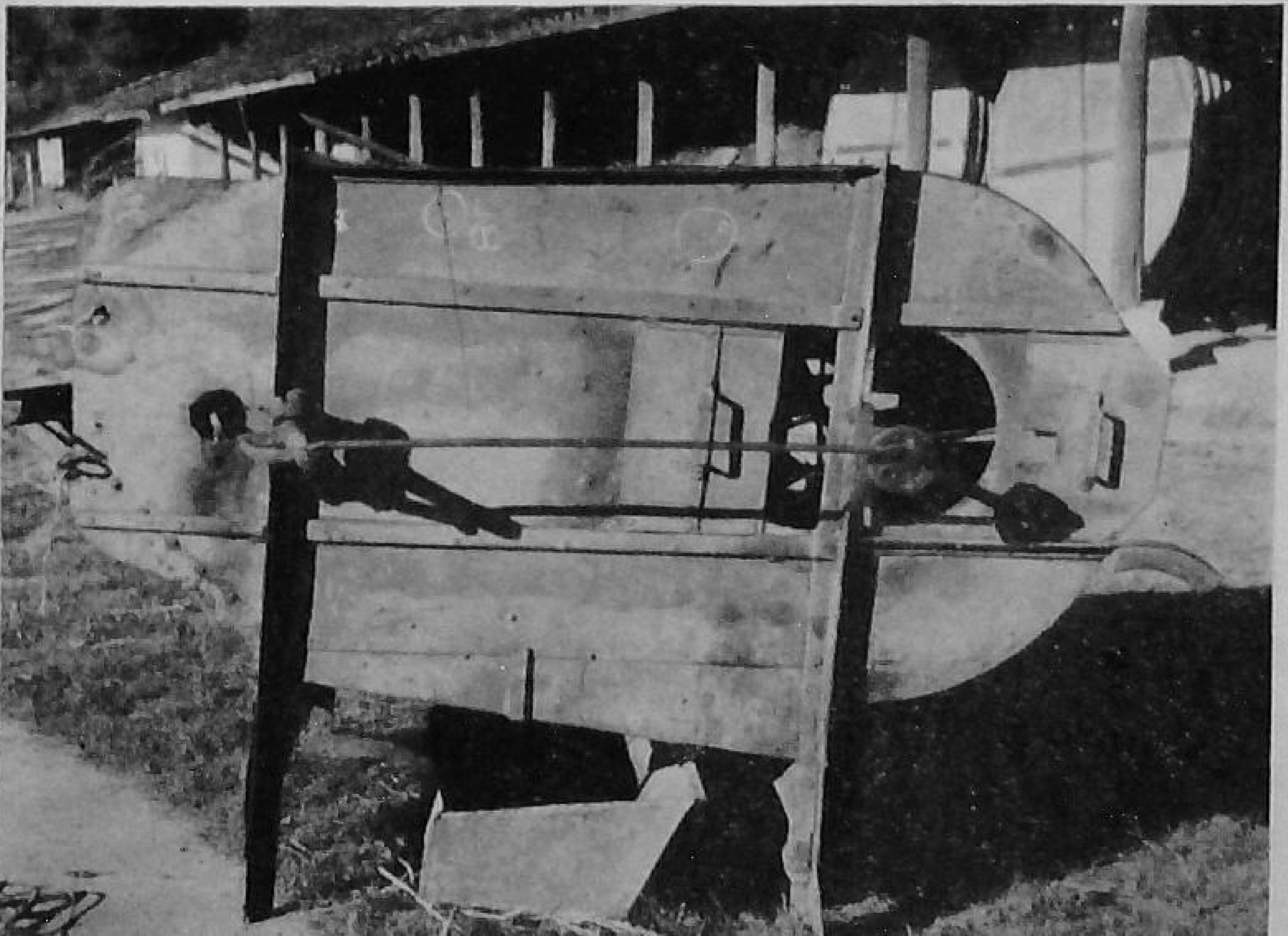
1. All bearings and moving parts of the winnowing machines should be properly cleaned and oiled.
2. For using winnowing machines, the operator must choose the correct set of sieves required for the crops which he desires to winnow.
3. While operating a winnower, the draught of the wind should be regulated by adjusting the doors.
4. Where a lot of winnowing is to be done, it is desirable to fix the winnower firmly on a concrete base.
5. When the winnower is powered by an electric motor or a diesel engine, a fast and a loose pulley should be provided and proper alignment should be maintained.
6. The winnowing fan should be locked after use.



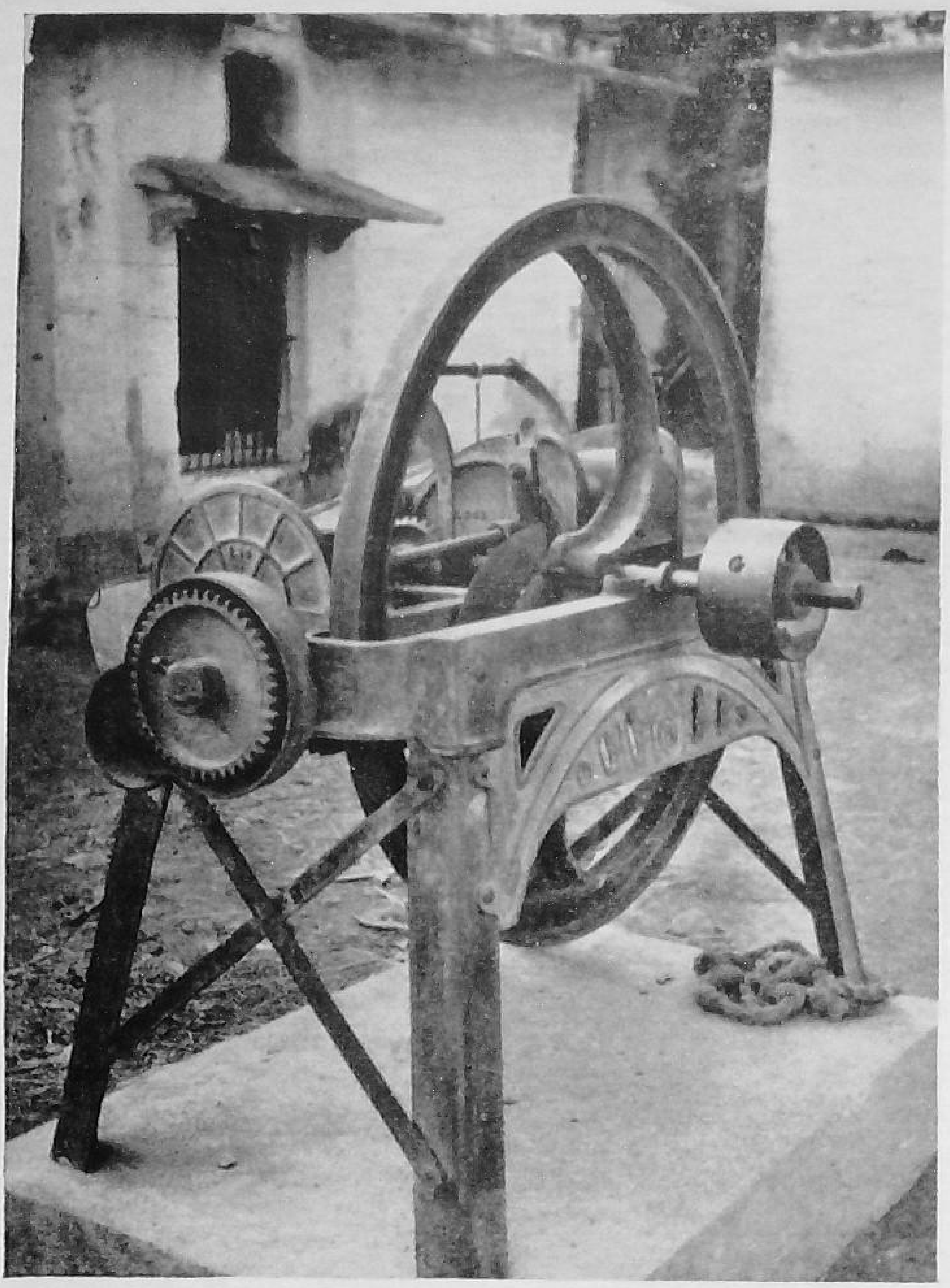
The Allahabad Winnowing Fan



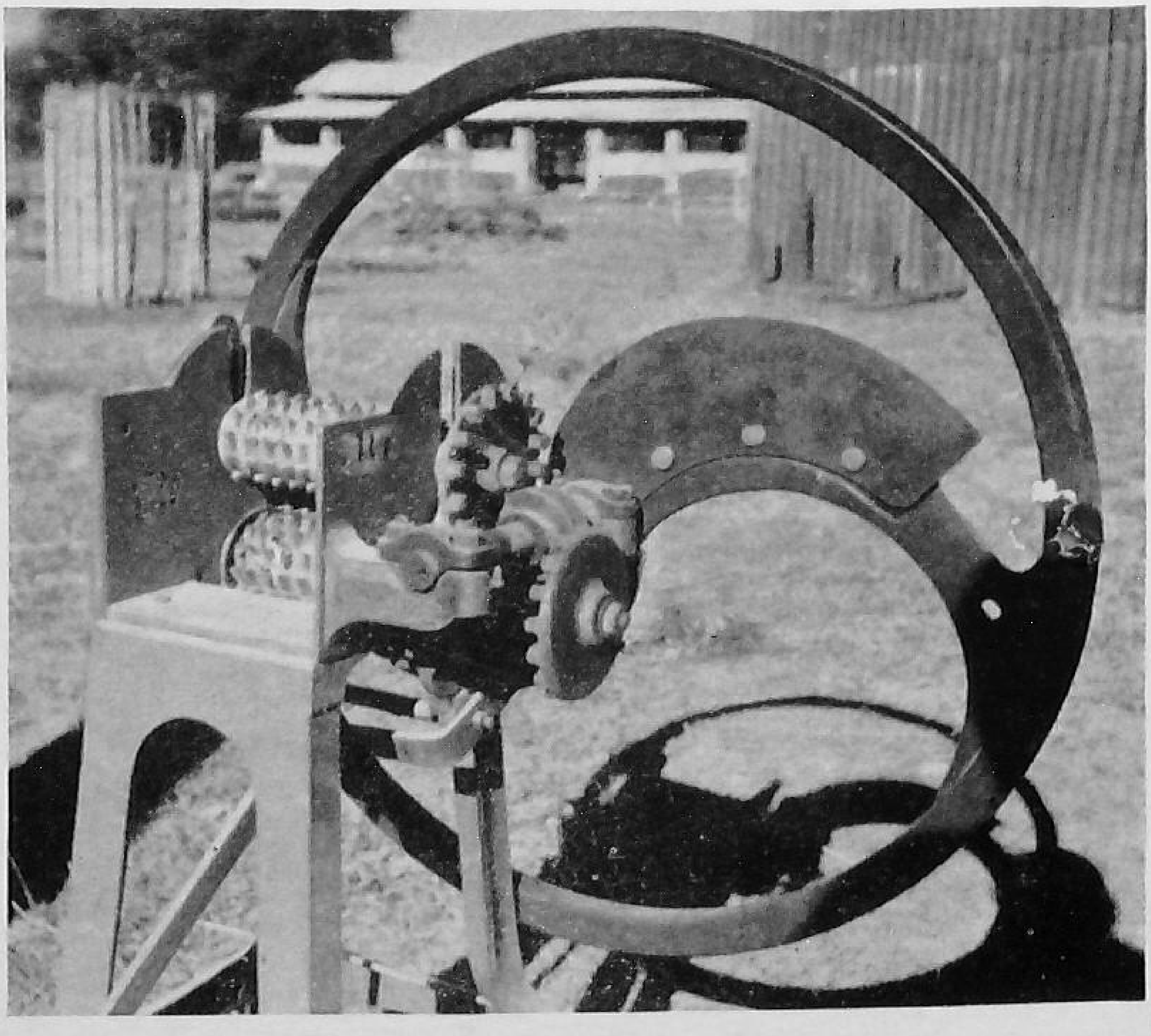
A Steel Winnower



The Rocking Mechanism of a Steel Winnower



A Circular Fodder Cutter



A Circular Fodder Cutter Showing its Mechanism

CHAPTER 10

FODDER CUTTERS

Indian farmers have long realised the necessity of cutting fodder before feeding it to cattle. Cut fodder minimises waste and makes the feed more palatable.

The traditional fodder cutter used by Indian farmers is a strong hatchet or a hand knife called *gandasa*, which costs approximately Rs. 3. However, cutting fodder by a *gandasa* is very tiresome and also causes wastage. Improved fodder cutters have, therefore, become popular in the country.

GOPURI (WARDHA) FODDER CUTTER: This machine was devised at the cattle farm of the Akhil Bharat Sarva Seva Sangh at Wardha. It consists of a big sharp knife which is made to work between two steel plates. The knife is attached below a pressure rod with a long handle. The cutter is very simple in construction and costs about Rs. 20. It is suitable for farmers having five to six head of cattle. It can easily cut the hard *jowar* stalk. A sheaf of *jowar* stalk is placed at right angles to the knife and after a portion of it is cut, the sheaf is pushed ahead. This cutter cuts fodder into pieces 7″ to 8″ in length.

SEVAGRAM FODDER CUTTER: The Sevagram fodder cutter designed at Sevagram, Wardha, is a simple *dhenki* type fodder cutter costing approximately Rs. 10. It can cut nearly 250 lb. of fodder per hour.

The fodder cutter consists of a sharp steel blade fixed firmly on a wooden beam. A flat wooden block, preferably of *babul*, is placed below the blade. At the other end, a shallow pit is constructed to take the end of the beam below the ground level. A stick is fixed in the ground to give support to the operator. The steel blade is usually 14″ × 3″ and the beam 9′ × 7″. It is pivoted at a distance of 6′ from the end at which the blade is fixed. An oil hole is provided on the axle.

Care should be taken that there is no play at the point of

the hinge and that the operator does not allow his hand or fingers to go inside the space covered by the beam. The lever, when not in use, should be locked to prevent accidents.

Lever Type Portable Fodder Cutter: This fodder cutter consists of a tripod or a four-legged stool on which a knife and a tray to hold the fodder is fixed. In front of the knife, a plate is fixed so as to adjust the length of the cut fodder. The handle is worked up and down. The machine weighs about 80 lb. and its price is about Rs. 25 to 50. It can cut sufficient fodder in one hour for about six animals.

Circular Fodder Cutters: The circular fodder cutter is an outstanding example of the improved implements introduced and popularised in India. Today they are being widely used throughout the country particularly in the Punjab and Uttar Pradesh. In some places they are being manufactured by ordinary blacksmiths.

Light, circular chaff cutters, intended for small dairies, consist of a stand, a body and a main wheel. The stand is constructed from angle iron and braces.

The body consists of the following main parts:

a. The rollers which take the fodder and feed it to the cutting blades automatically. These rollers are revolved by means of a gear arrangement and once they grip the fodder, there is no necessity of pushing it forward.

b. The sides which consist of two cast iron plates which hold the rollers.

c. The shaft which runs in two ball-bearings and takes the main wheel. It is usually $1\frac{1}{2}''$ in diameter.

d. The gears which engage the worm on the shaft and rotate the bottom rollers for automatically feeding the fodder.

e. The front plate which is machined.

f. The spring which is attached to the top roller and which allows it to move up and down as the volume of fodder is increased or decreased.

g. The main wheel, which is at least $2\frac{1}{2}'$ to $3\frac{1}{2}'$ in diameter, weighs about 50 to 60 lb. Two high carbon steel scroll-pattern knives which give a continuous cut are attached to the main wheel by means of two sets of bolts. One set is made

for holding the blades and the other for adjusting the level of the blades in relation to the front plate. A wooden handle is provided for rotating the main wheel.

Good machines usually have two worms to cut two lengths of chaff. The normal length of the cut is 3/8″.

For driving the fodder cutters by means of bullocks, various types of bullock gears are available in the market. These usually consist of a main bed plate on which a big gear 3′ in diameter having about 100 teeth is mounted. This gear meshes with a small gear having ten teeth which is cast integral with a bevel gear of 18″ diameter with 60 teeth. This bevel gear meshes with another bevel gear with 15 teeth which rotates an 11′ long horizontal shaft. This shaft is joined with the centre of the chaff cutter's main wheel by means of two pairs of universal joints. With one round taken by the bullocks the chaff cutter wheel makes 25 revolutions, giving 50 cuts with its two knives. The approximate output of such chaff cutters is 1,600 to 3,000 lb. depending on the type of the fodder cut and the speed of the bullocks.

Rod gears of steel and mild steel rounds and flats of suitable sizes are also used in the bullock gear instead of cast iron gears.

A bullock-driven belt mechanism is also available.

Bigger, circular fodder cutters are driven by power. In these, fast and loose pulleys for the transmission of power and a belt arrangement to push forward the fodder are provided. A heavy spring is also provided in the bracket on the top of the body, which helps in moving the cap up and down. Heavy ball-bearings are provided on the main shaft.

It is necessary to prepare a solid foundation for the power-driven chaff cutters. The level of their main shafts should also be carefully fixed. Their blades should properly touch the front piece. The maximum speed of the power-driven chaff cutters should be between 200 and 250 revolutions per minute. The approximate weight of such machines is 300 to 325 lb. They can cut between 160 and 204 mds. of fodder in eight hours. These machines require 2 to 5 h.p. engines or electric motors.

Care and Precautions

Chaff cutters have to withstand a good deal of rough work. Their bearings should be properly cleaned and oiled before starting the work. The blades also should be sharpened whenever required. Care should be taken to see that the worm and the gears do not jam, otherwise the life of the gears will be shortened. The chaff cutters used on farms and dairies are rather dangerous as their blades are extremely sharp. Utmost care should, therefore, be taken to lock the wheels when not in use, so that they are not rotated by unauthorised persons or children.

CHAPTER 11

PROCESSING MACHINES

After the harvesting and threshing are over, the agricultural produce is processed before marketing. For this purpose, processing machines like groundnut decorticators, maize shellers, paddy shellers, etc., are available. While processing, it is necessary to take into consideration the type of grain, its moisture content and other factors. It is for this reason, that for each crop a separate machine is used.

GROUNDNUT DECORTICATORS: After groundnut is harvested, the crop is kept in the open for drying and the pods separated from the plant. These are again dried and the operation of extracting the seed from the pods is undertaken. At present, in the villages this is done only by hand. But a number of machines have been designed by means of which the work can be done economically and efficiently.

The simplest decorticator available for this purpose is the one designed in the laboratory of the Akhil Bharat Sarva Seva Sangh at Wardha, which has been awarded a special cash prize by the Indian Central Oilseeds Committee. The machine can be manufactured by a village carpenter. It consists of a table-like stand and a semi-circular sieve in which a wooden drum is rotated. The pods are rubbed between the outside of the drum and the inside of the sieve and the seed is extracted and separated from the shells. The separated seed falls through the apertures in the sieve. The cost of this machine comes to about Rs. 60, and its capacity is two bags of groundnut seed per hour.

Another drum type decorticator for groundnut is also available. It costs about Rs. 100 and consists of a cast iron drum which is placed inside a semi-circular sieve. The sieve is replaceable and can be changed according to the size of the seed, which differs considerably from variety to variety. The drum is rotated by means of a fly-wheel and a handle,

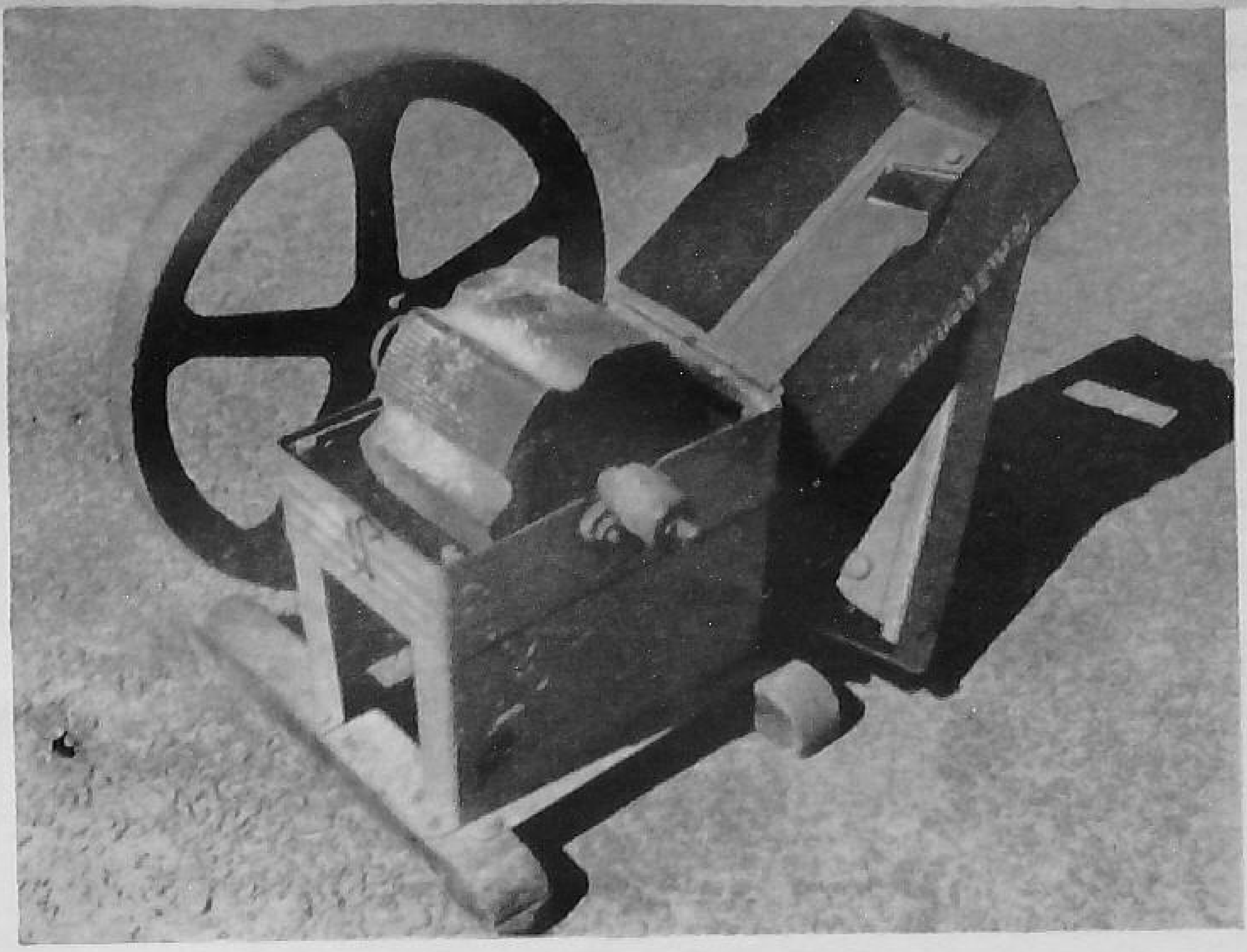
and is placed on two ball-bearings. The sieves which are known as grates have apertures of 5/16", 11/32", 3/8" and 13/32". The net weight of the machine is 107 lb. and the output at 100 revolutions per minute 80 lb. per hour. As the machine is made from steel, it is durable and sturdy. For optimum work it should be revolved at 60 revolutions a minute. At this speed the machine shells ten bags of groundnut in eight hours.

A bigger hand-driven machine can thresh 24 bags in eight hours. It costs Rs. 200. In it, power is transmitted by a belt, and a fan is provided for cleaning the seed. The hand-driven machines are meant essentially for small farmers. For big farms, a machine, in which the upper crust of the seed or the seed-coat is peeled off and the seed is separated from chaff and dust, is available. This machine shells about 70 to 80 bags of groundnut per hour and it has an automatic feeding mechanism. Its price is Rs. 250 and it is run by a 2 h.p. electric motor or an oil engine.

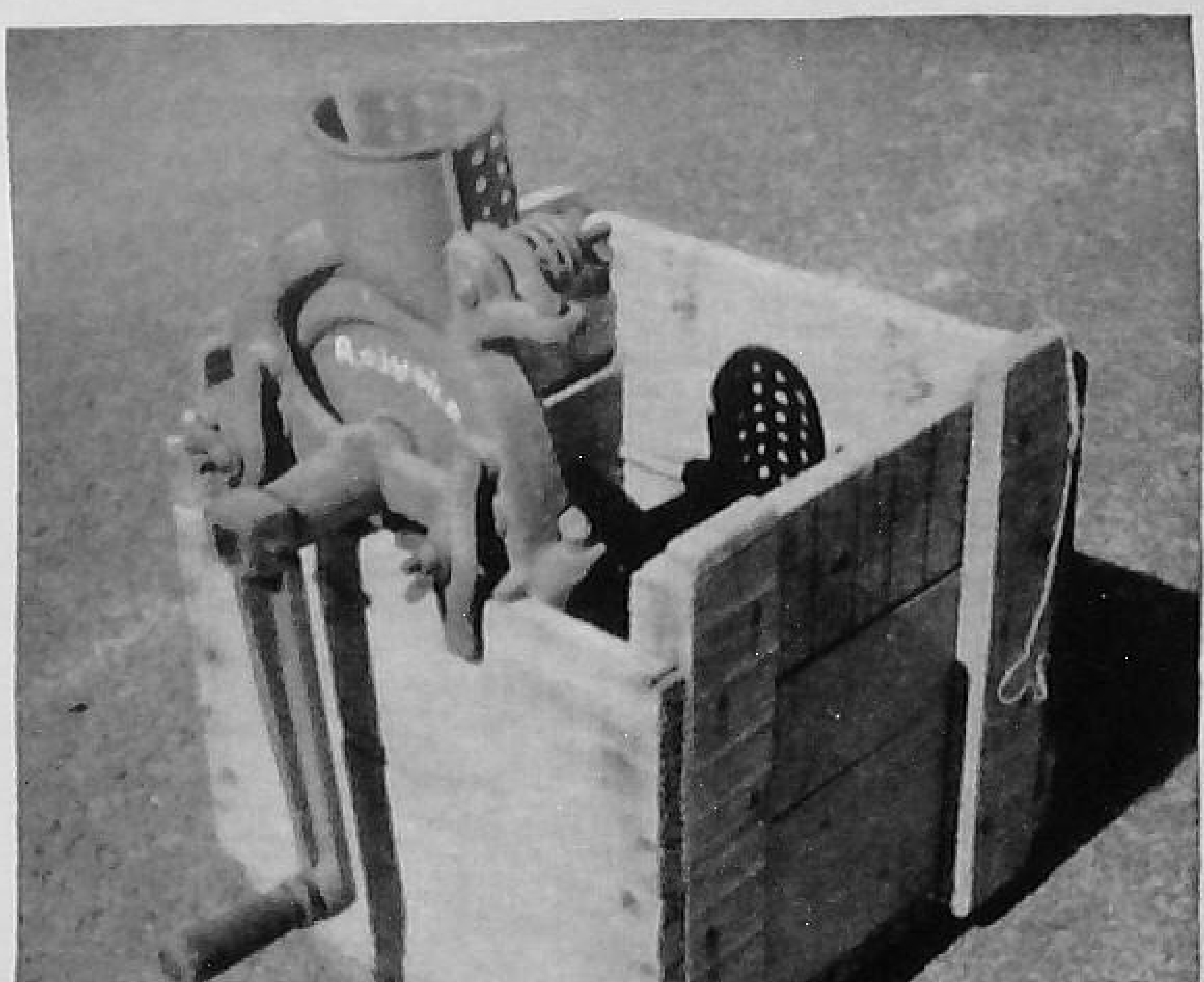
CORN SHELLERS: Maize is an important crop, particularly in the Punjab, north Rajasthan, Bihar and Uttar Pradesh. For separating the maize seed from the cob, a simple machine has been designed.

It has a big wheel having teeth on one of its faces. The cob is inserted in the hopper which grips it. This grip, under tension, adapts itself to the various sizes of the cobs of maize. When the wheel is revolved, it catches the grain in its teeth, and the cob is shelled. The grip is hinged to the main body. The machine is so made that it can be clamped on to a small stool or a wooden desk. About 1,000 lb. of corn per day can be shelled by a man with this machine. The machine weighs approximately 15 lb. and costs about Rs. 50. Where maize is grown on a large scale, a power-driven machine proves more useful. Such a machine is usually fitted with a blower which is worked by a leather band from the main spindle.

TURMERIC POLISHER: In Andhra and Madras, turmeric is grown extensively. Before marketing, turmeric is polished. For this, it is placed inside the circular sieve of a turmeric polisher which is rotated. The sieve is made from expanded

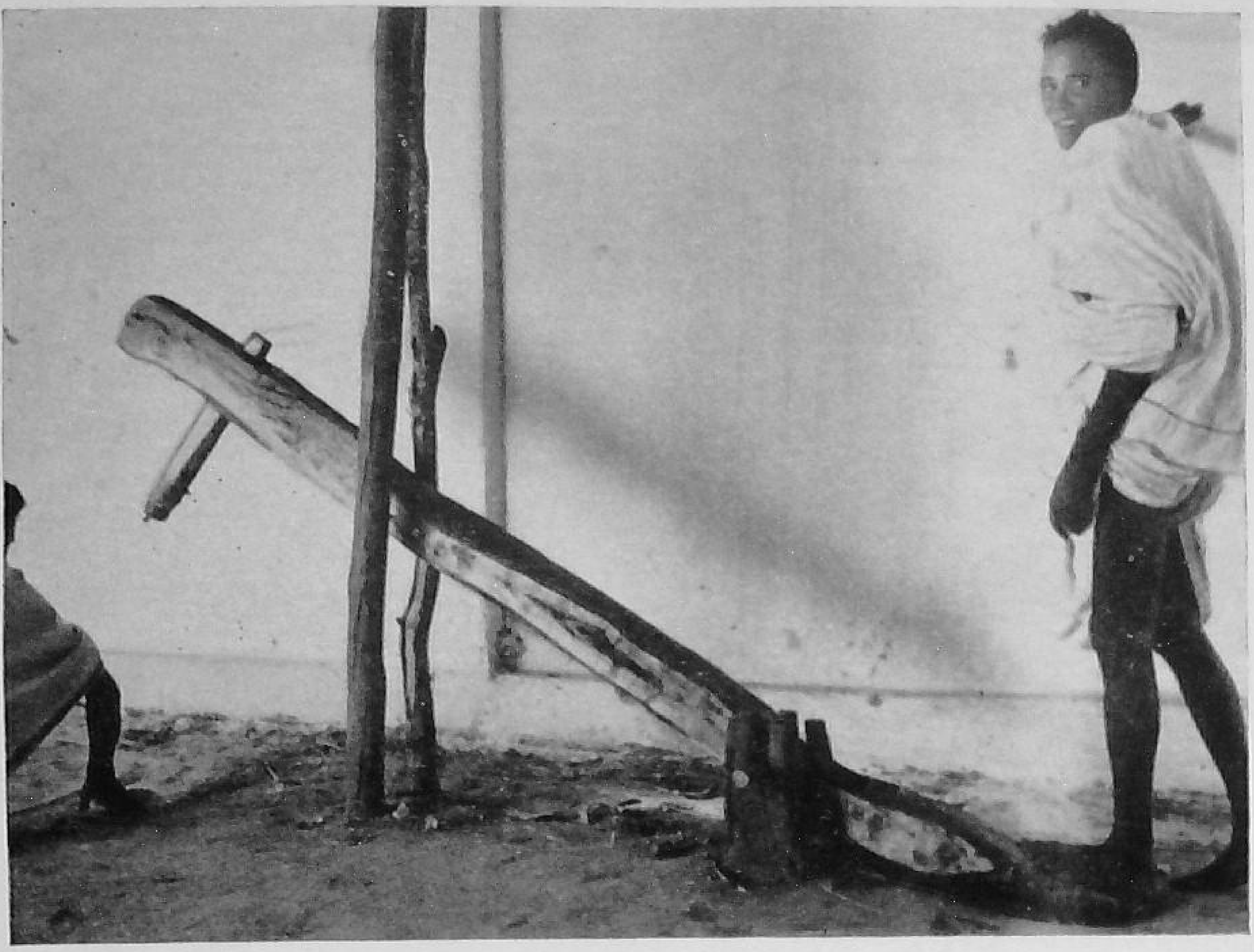


A Groundnut Decorticator

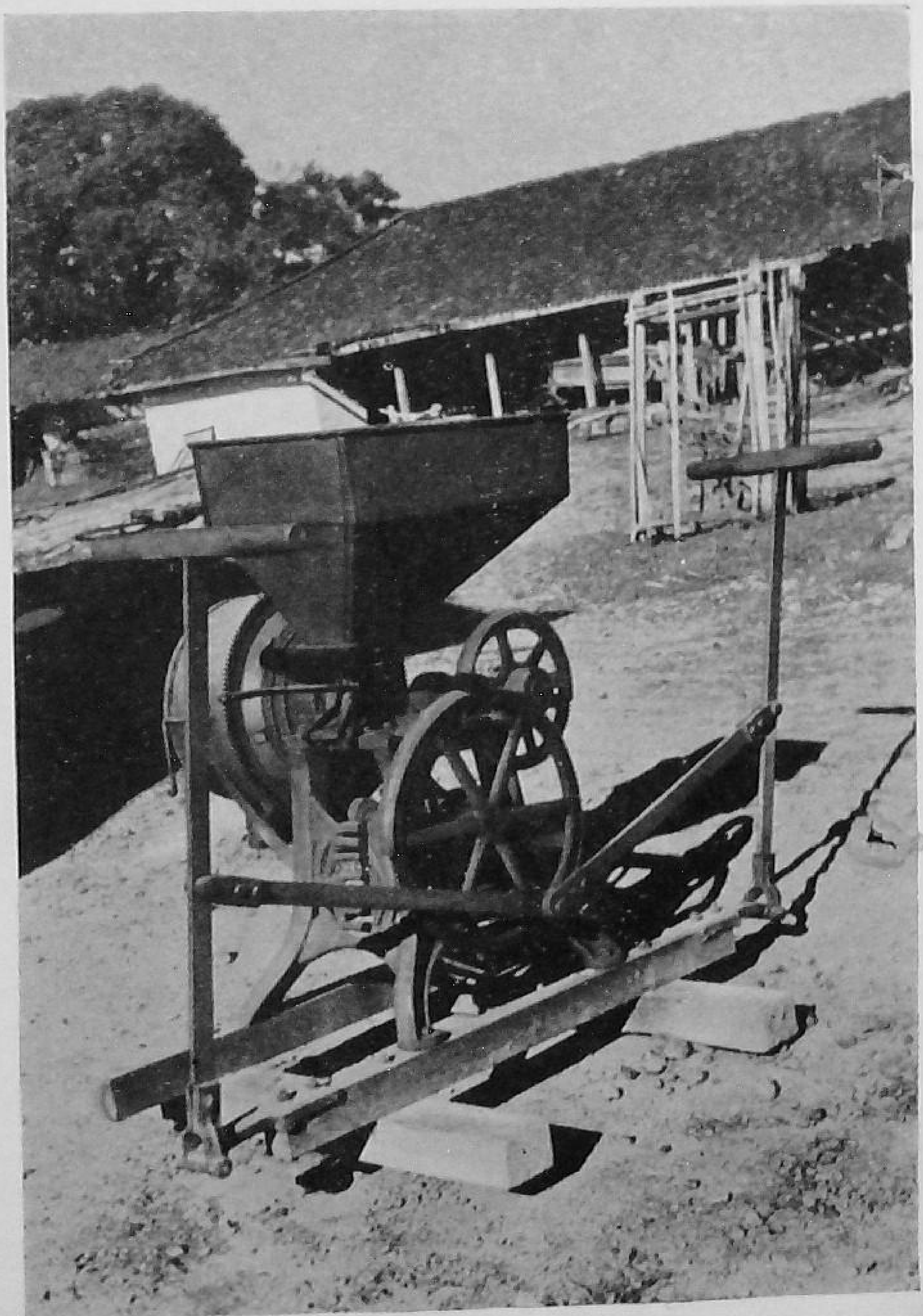


A Corn Sheller

A Corn Sheller Showing its Mechanism



A Dhenki Type Paddy Sheller



A Japanese Paddy Sheller

metal and the friction that is created between turmeric and the sieve does the polishing. The approximate cost of this machine is Rs. 50.

Cotton Gins: Big cotton gins have become very common in the cotton growing tracts. But, for separating cotton from seed in small quantities, particularly for breeding purposes, it is necessary to have a small cotton ginning machine which is worked either by hand or by power. Such a machine works on the principle of the power gins. It is claimed that it separates the fibres without injury to the seed. The seed separated by this machine is, therefore, very useful for sowing purposes.

Paddy Shellers: A *dhenki* type paddy sheller used in the villages costs Rs. 4 to 5 and requires two men to work it.

The Japanese type of paddy sheller which shells paddy by impact action has been found to be very useful in India. In this machine, paddy is fed through a hopper to a rapidly revolving vertical disc. As the paddy grains fall on the disc, the husk gets broken due to the impact. The disc is revolved by means of a series of gears and two levers. If paddy is of hard type, it has to be put through the machine twice. The machine is simple in construction and is operated by two men. Its cost is about Rs. 180.

Sugarcane Crushers: The modern sugarcane crusher is worked either by bullocks or by oil engines. The construction of the crusher in both the cases is similar, except for the drive mechanism required for the oil engine crusher.

Bullock-driven crushers are usually small in size and can be worked by a pair of bullocks. They have three rollers manufactured from a special grade wear-resisting metal. The rollers have their surfaces made rough by parallel or cross indentation. The roller shafts are manufactured from good quality steel, and they revolve in gun metal bearings. The frame work is made from high grade cast iron. All the three rollers have gears on the top. Bullocks are hitched to the crusher by a beam which is fixed on a steel coupling.

In good machines, scrapers are fixed to the rollers and a specially covered plate is fitted so that the crushed cane does not enter the bottom tray and get mixed with the juice. The

percentage of extraction by these machines is 40 to 60. The sugarcane crusher should be fixed properly in the soil by using two pieces of wood 6′ long, 5″ wide and 4″ thick. The approximate cost of a sugarcane crusher is Rs. 550 to 650. Engine-driven crushers are still costlier.

Next to the mould-board plough and the circular chaff cutter, probably the sugarcane crusher is the best example of an improved agricultural implement accepted by Indian farmers. It is estimated that in Uttar Pradesh alone, over 80,000 bullock-driven sugarcane crushers are in use at present.

CHAPTER 12

IRRIGATION APPLIANCES

DHENKI: Appliances of the *dhenki* type have a lever arrangement where a long pole, about 16′ in length, is pivoted on a vertical pole in such a way that mechanical advantage on the principle of the lever is obtained. On one side of the horizontal pole an appropriate weight is fixed with a rope and on the other side a bucket. The weight is to counter-balance the bucket. This appliance is suitable only for wells or canals where the water level is about 10′ to 15′ below the ground level. It cannot work at a greater depth. The cost of such a unit comes to about Rs. 8.

WATER SCOOP: A water scoop is prepared out of bamboos or weeds and is tied on the central portion of a tripod. It is mostly used in south India for lifting water from shallow canals to a height of about 1½′ to 2′. It costs about Rs. 3. It is only suitable for irrigating small areas up to 1/4 to 1/2 an acre.

HOLLOW TREE TRUNK: A boat shaped trunk of a tree such as that of coconut, is used to lift water from shallow heights. It also employs the principle of a lever. Water is lifted at one end and carried to the other. The cost of a unit comes to about Rs. 6. It is suitable for irrigating small areas up to 1/2 an acre.

MHOT: A leather *mhot* is probably the most commonly used irrigation appliance in India. *Mhots* are worked by bullocks and with their help water is lifted even from a depth of 150′. A *mhot* consists of a bucket, with or without a spout, which is lifted over two pulleys by a pair of bullocks. The capacity of the bucket is usually 25 to 35 gallons, depending on the depth of the well. The *mhot* costs about Rs. 30.

There are two types of *mhots*, one with a spout and the other without a spout. The *mhot* without a spout requires two persons to handle it, whereas the *mhot* with a spout needs only one. The top pulley usually has a bigger diameter, ranging

from 1′ to 2′, than the bottom roller pulley which usually has a diameter of 6″. Where the wells are deep, the bullocks are unyoked, turned round facing the well and driven towards it to lower the empty *mhot*. But, if the wells are not very deep, the bullocks are driven backwards.This method, however, reduces the life of the bullocks. *Mhots* can irrigate one to three acres a day.

PICOTAH: In Madras and Kerala, a big beam known as *picotah,* which is fixed horizontally on a pole, is used for lifting water. It is similar to a *dhenki* and works on the principle of a lever. Here, workmen walk on the beam, near the hinge, forwards and backwards, to lower and lift the bucket attached to one end.

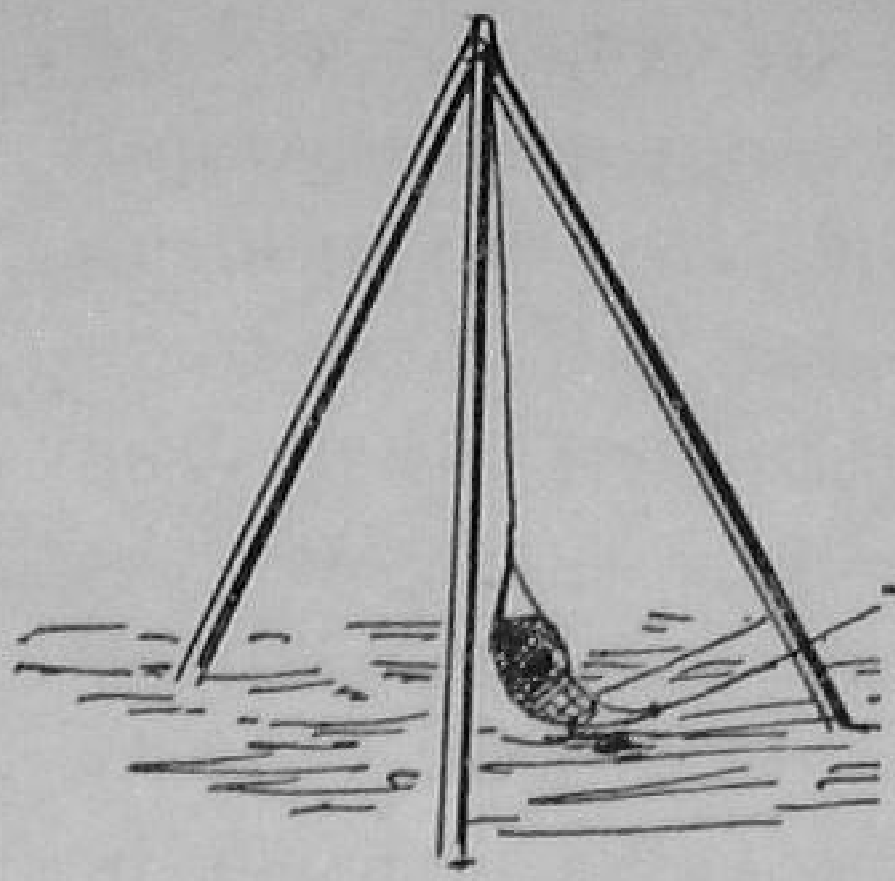
Improved Appliances

During the last four or five decades, efforts have been made to introduce a number of improved irrigation appliances in the country. Following are some of them.

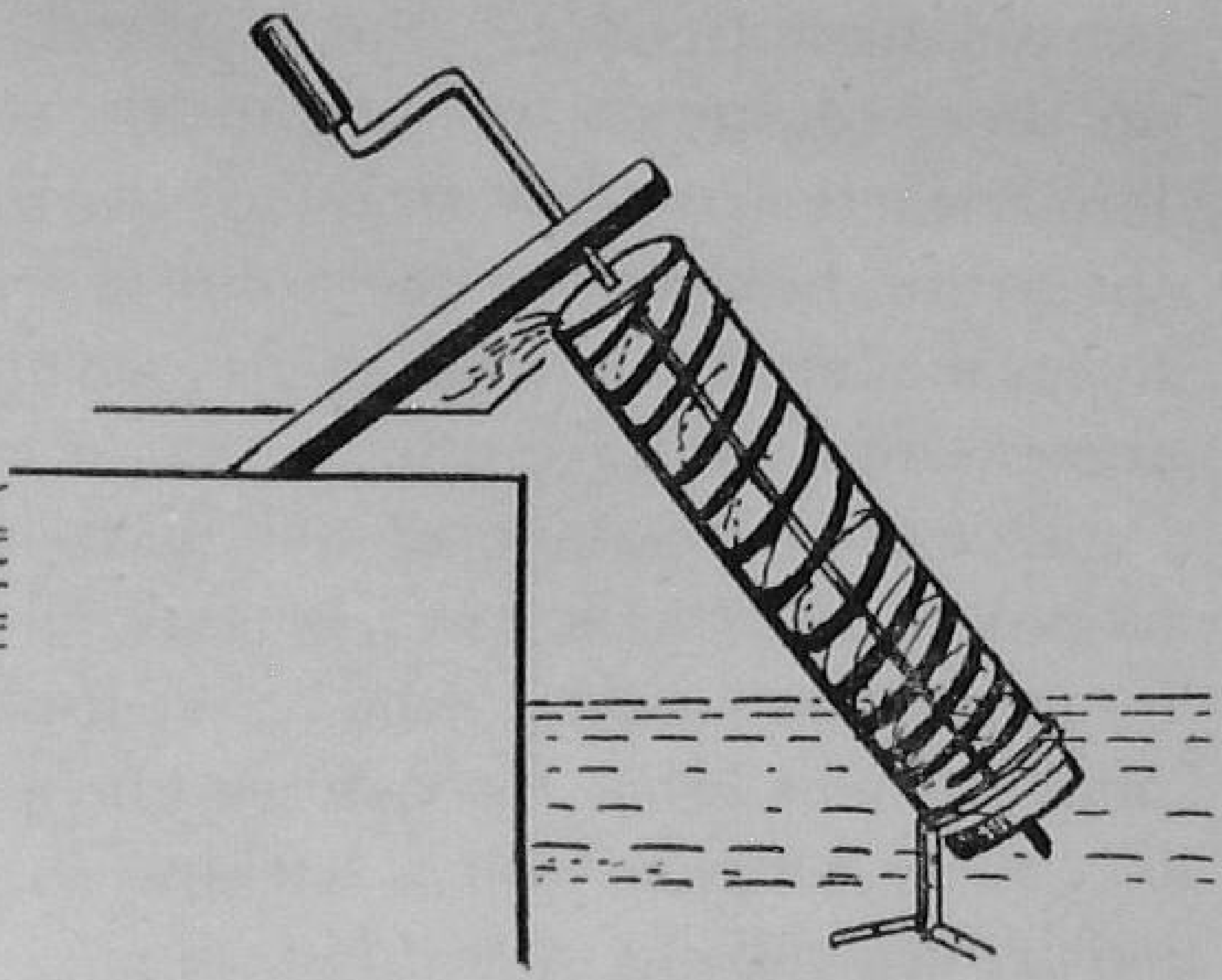
ARCHIMEDEAN SCREW: The Archimedean screw has not proved popular because it cannot be used except to draw water from very shallow channels and it is rather difficult for village carpenters and blacksmiths to manufacture. It consists of a screw-like arrangement placed inside a tube. When the apparatus is rotated, the curved plane of the screw lifts a certain amount of water which comes out through the hole at the top.

PERSIAN WHEEL OR RAHAT: Among the improved irrigation appliances, the Persian wheel or the *rahat* has become very popular in India. It is manufactured by a number of firms and its cost ranges from Rs. 400 to 900 according to the size of the buckets and the length of the chain used.

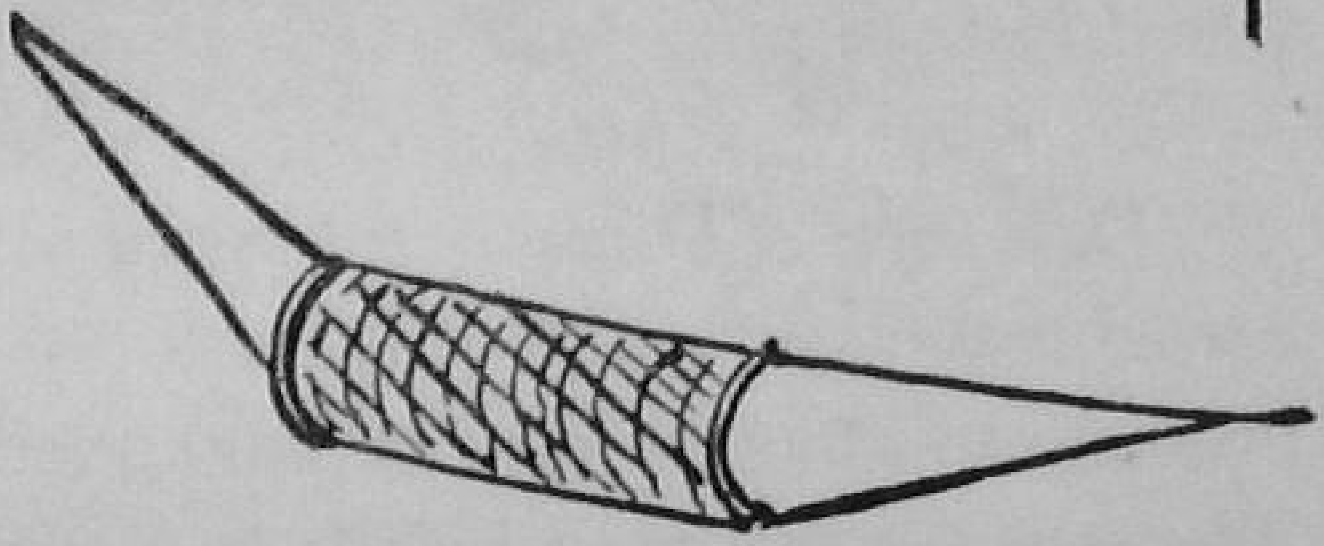
The construction consists of a circular drum of about 2′ to 5′ diameter, which is rotated by a pair of bullocks with the help of bevel gears. On this circular drum a chain of buckets is kept hanging. When the drum is rotated the buckets bring up water and drop it in a tray from where it is carried to the field. In the place of bevel gears of cut teeth type, ordinary gears prepared from rods can also be used. But



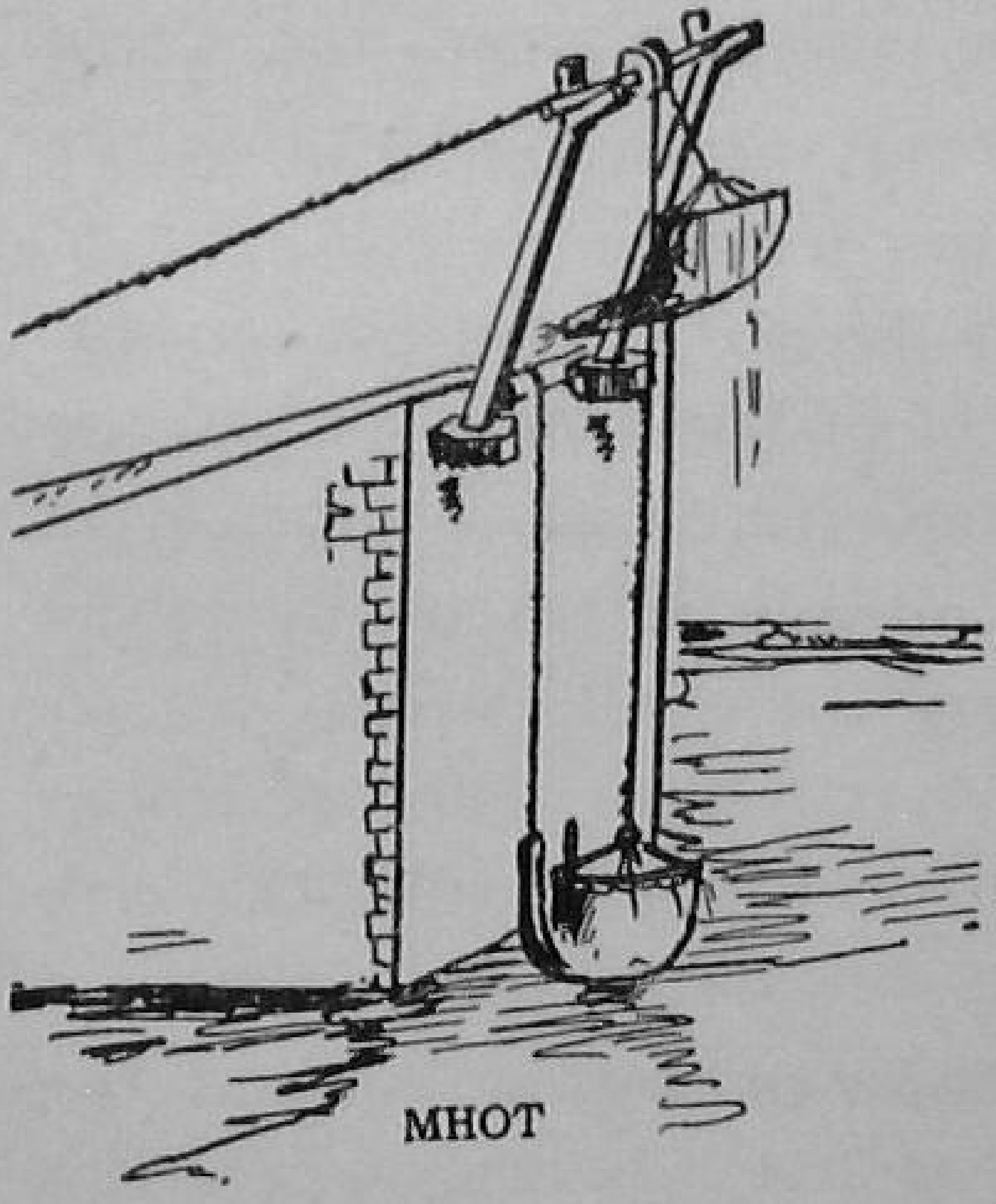
WATER SCOOP



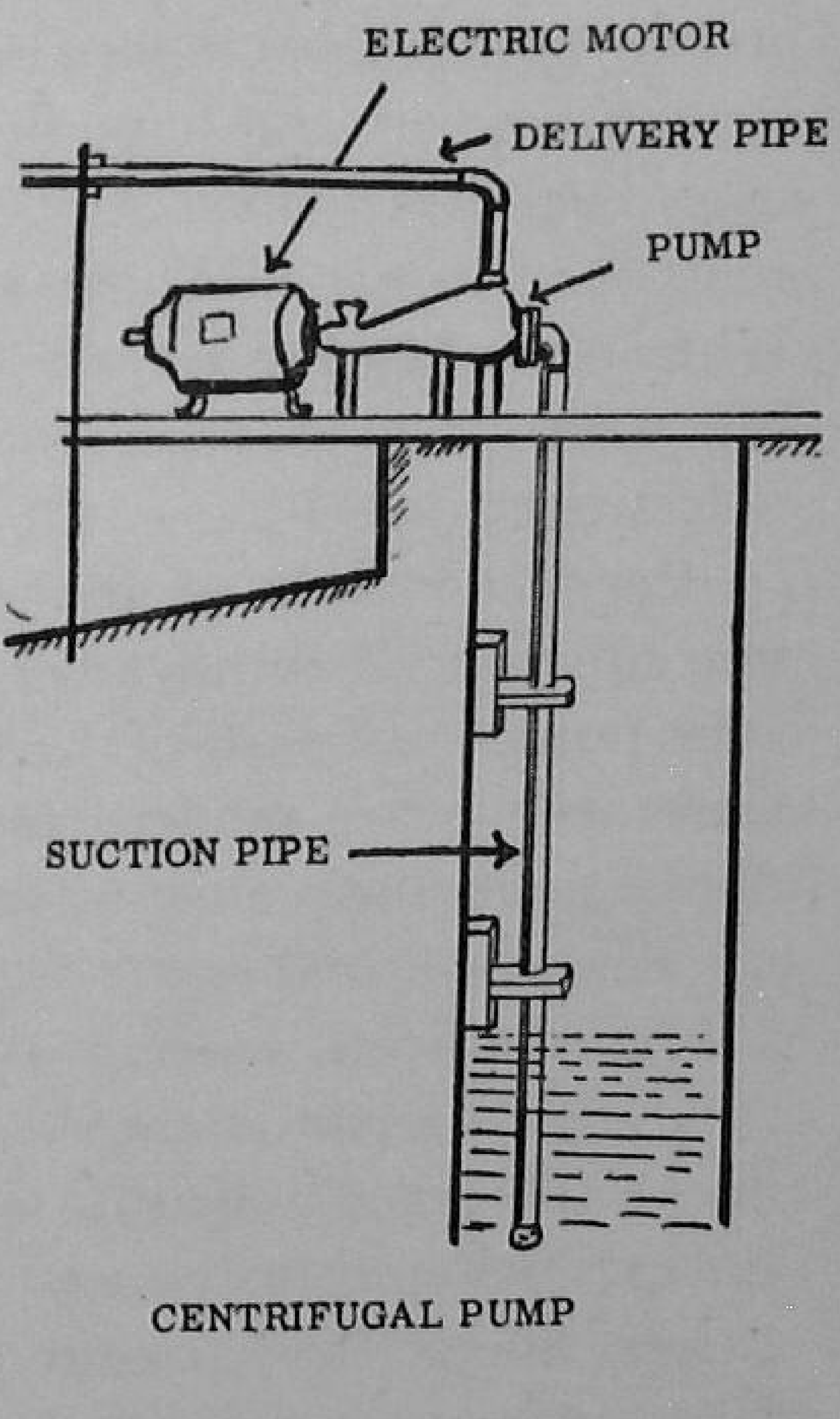
ARCHIMEDEAN SCREW



SWING BASKET



MHOT



CENTRIFUGAL PUMP

it is better to have bevel gears. The frame supporting the gears is made from 'H' iron of $4'' \times 3''$ size. The driving rod has three bearings made of gun metal with ring lubrication. The buckets are made from galvanised sheets. In order to obtain the best results, the bullocks should be attached at a distance of about 11′ from the centre of the vertical axis. The capacity of each bucket in the chain is usually 1½ gallons to 3 gallons. The output of the *rahat* ranges between 3,500 gallons and 7,000 gallons per hour.

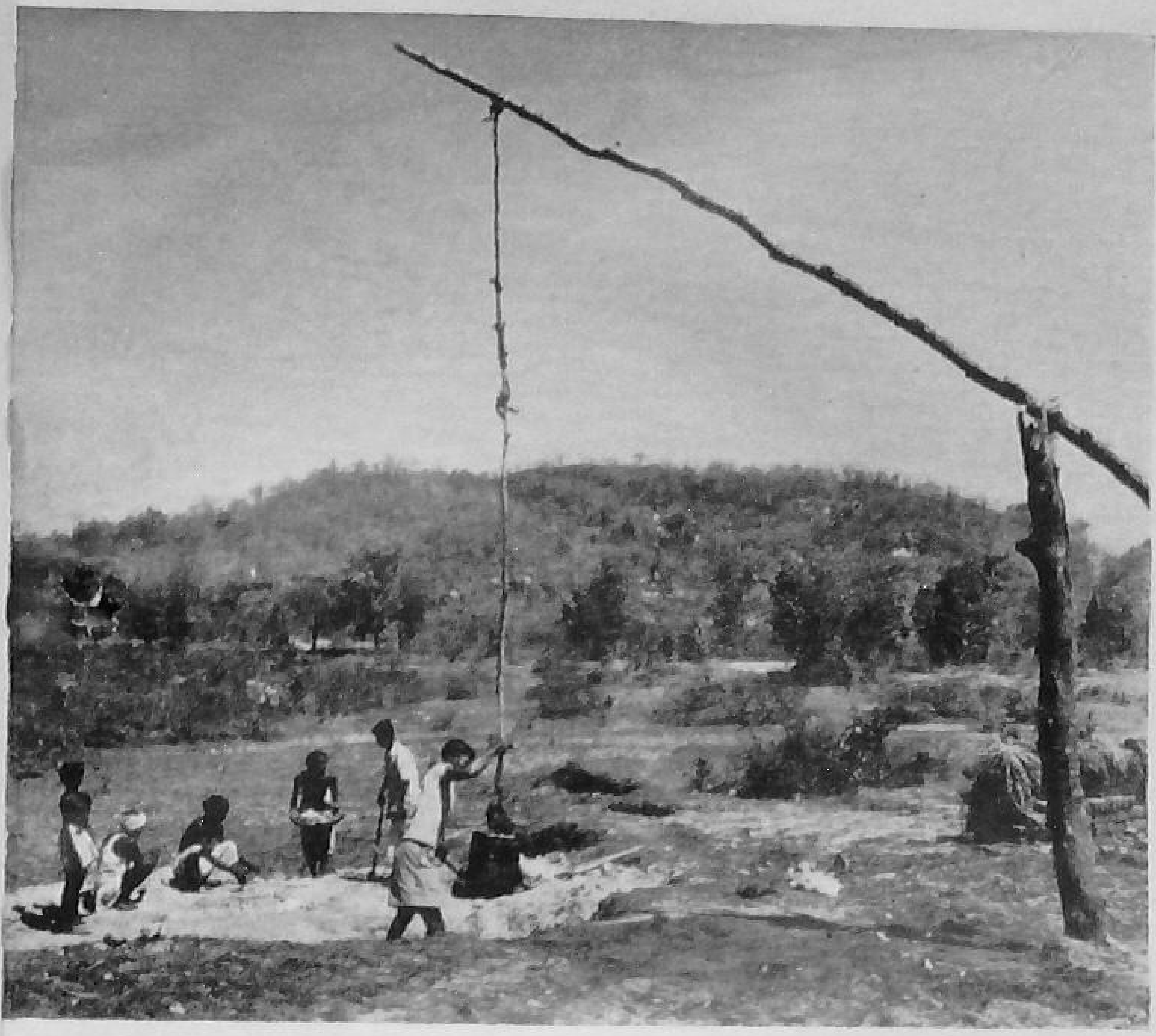
Small hand-driven *rahats* are also available for use in small gardens or in institutions like schools. Smaller *rahats* have been designed which do not require any driving shaft and are centrally fixed and bullocks are made to go round the well. In certain designs two *rahats* are attached to two sets of driving gears. Shri Maya Das, former Director of Agriculture, Uttar Pradesh, has designed improved *rahats* of these types.

IMPROVED MHOTS: Sheet metal *mhots* have replaced leather *mhots* in many areas. The metal *mhots* may be of the ordinary bag type with a short spout. They cost about Rs. 60 each.

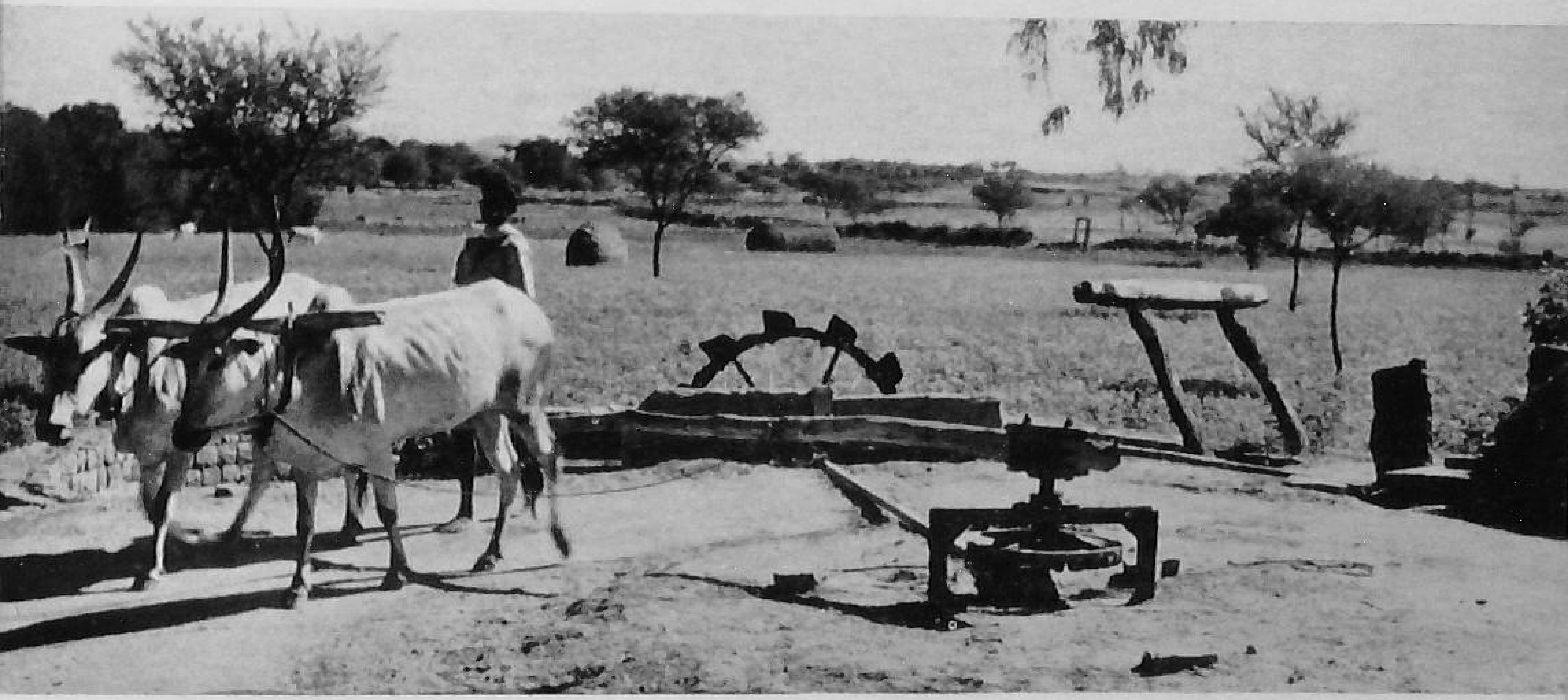
The *mhot* pulleys have also engaged the attention of the research workers and have been improved. Both roller-bearing and ball-bearing *mhot* pulleys are now available which cost about Rs. 30 each. There is an arrangement for putting grease in the bearing and the use of greased ball-bearing *mhot* pulleys considerably reduces the strain on the bullocks.

CENTRIFUGAL PUMPS: Of all the modern irrigation appliances, centrifugal pumps probably are the simplest and most efficient. They have become popular with the farmers. These pumps make use of the high speeds obtained by electric motors and other modern prime movers to lift water. The following are their chief advantages.

1. Low initial cost
2. Very few wearing parts
3. Low maintenance cost
4. Direct attachment to a motor or engine
5. Noiseless operation
6. Small floor space requirement
7. Constant flow of water

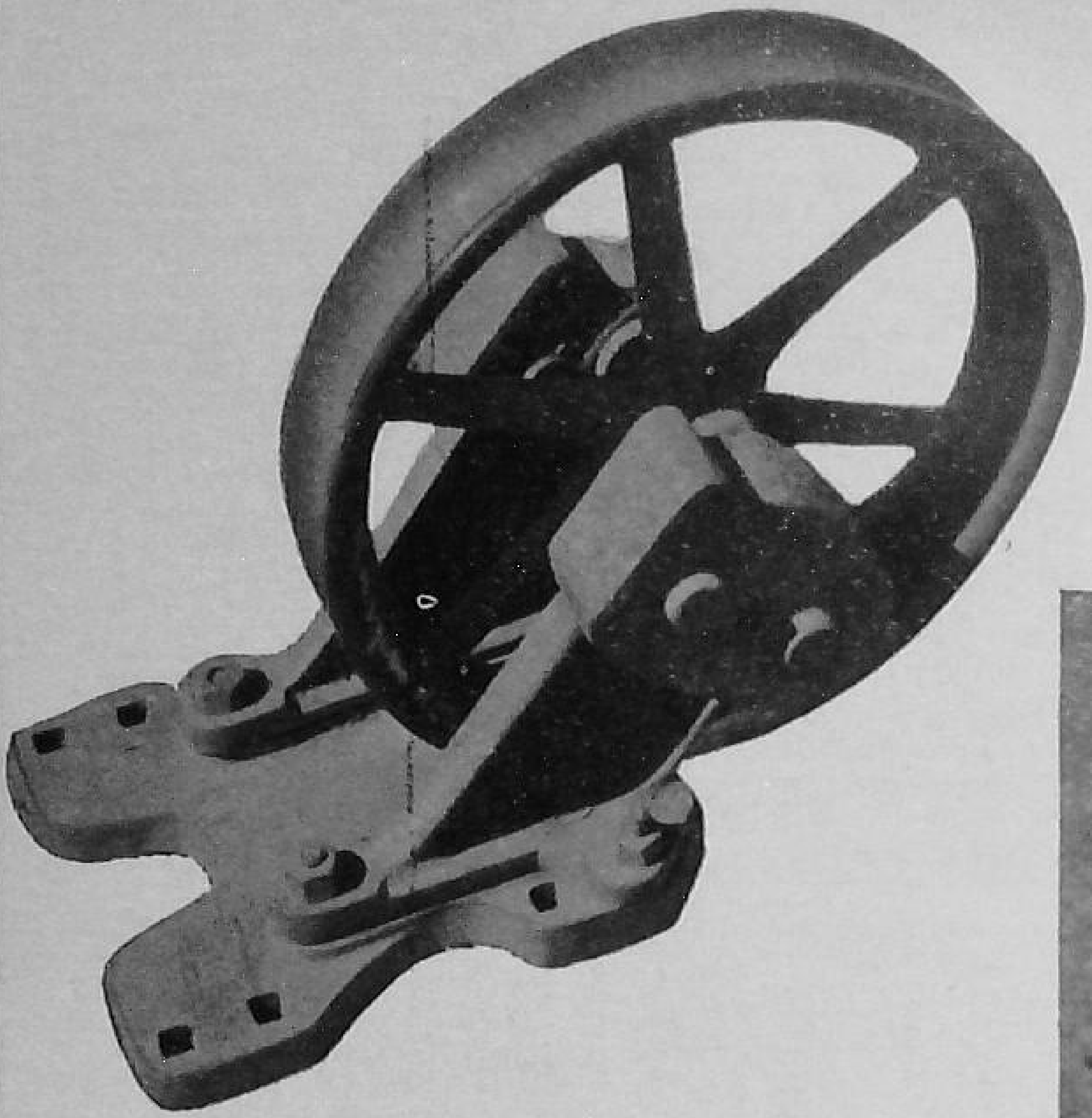


A Dhenki Type Water Lift

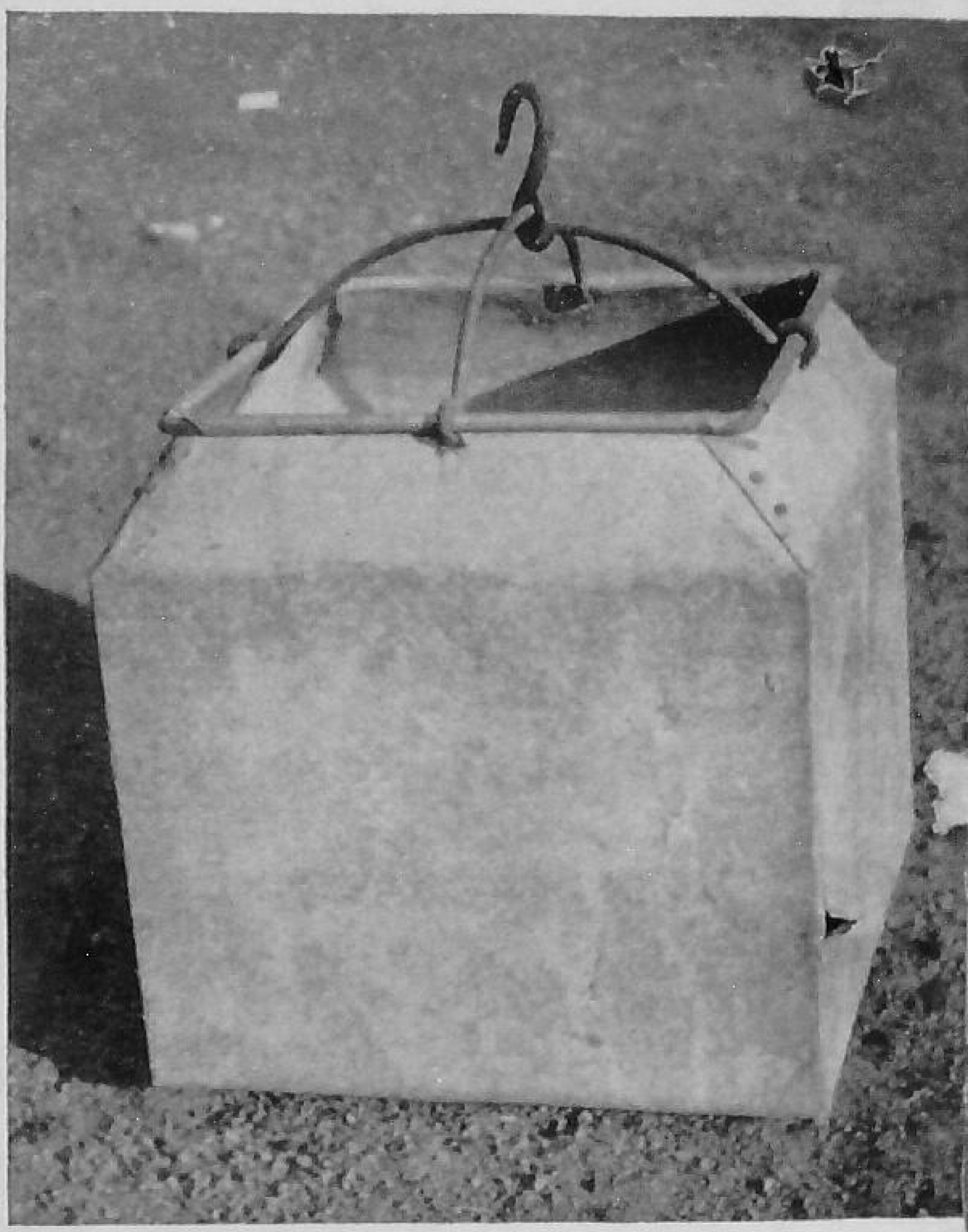


A Persian Wheel or Rahat

A Boat-shaped Water Lift or Don

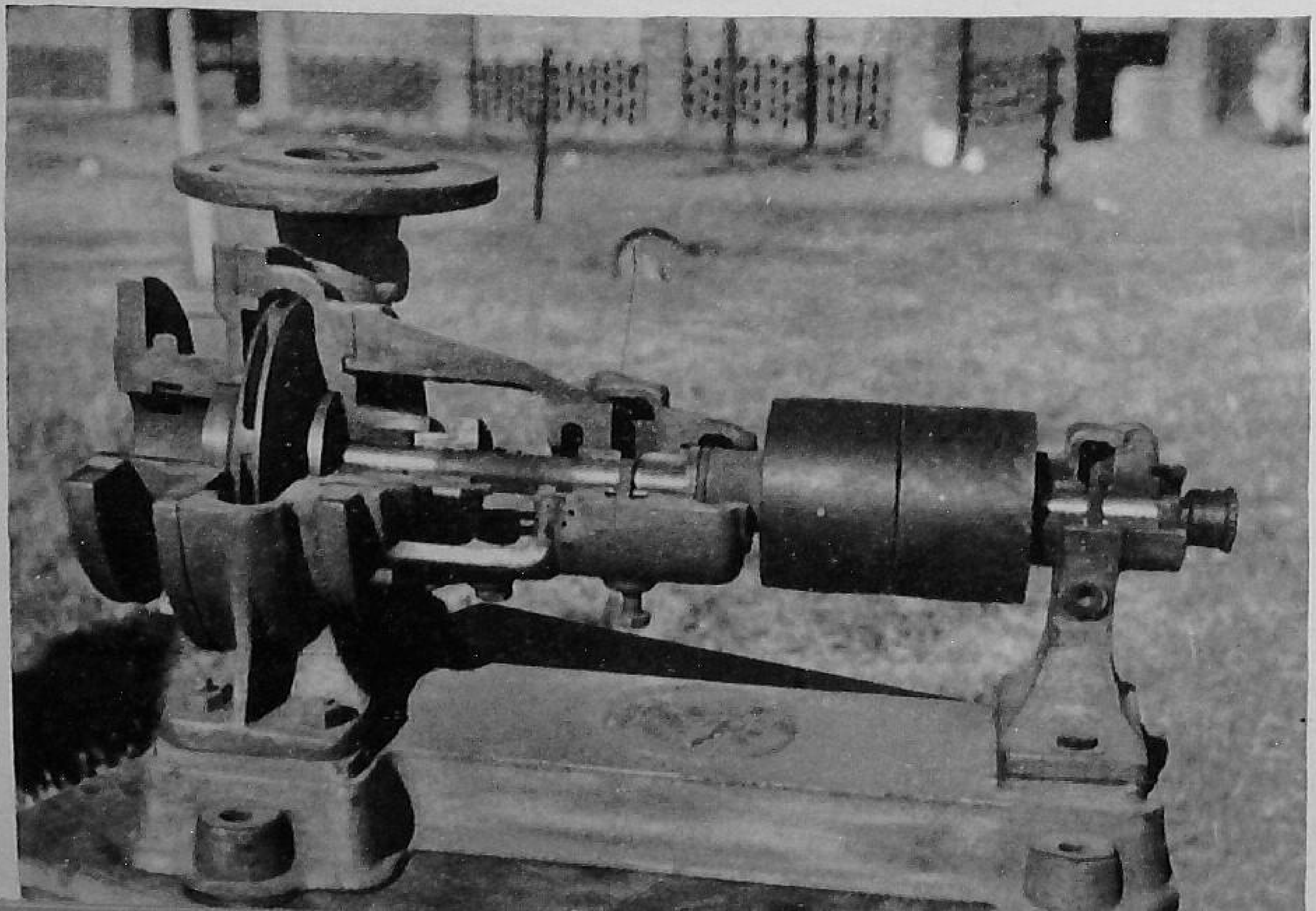


An Improved Mhot Pulley



A Metal Mhot

A Cut-out Model of a Centrifugal Pump



A centrifugal pump usually consists of an impeller, a spindle and a casing. The impeller, which is fitted with blades or vanes, speedily rotates inside the casing which has a volute or a whirlpool chamber. As the impeller revolves, water in it is thrown into the volute by centrifugal force. When the water is thrown away from the centre of the impeller, a partial vacuum is created at the centre. There is atmospheric pressure on the surface of water at the suction point and this atmospheric pressure, in combination with the vacuum that is produced inside the casing, lifts water. It is then discharged through the delivery pipe. As the pump works through vacuum, it is obviously necessary to drive out all the air in it and the pipes by priming before it is operated.

In operating a centrifugal pump, the following points should be carefully noted.

1. The pump will not work unless it and its suction pipe are completely filled with water and all the air inside is removed.
2. The suction lift should be kept down as low as possible because a high suction lift decreases the capacity of the pump.
3. The suction and the pressure of a centrifugal pump depend on the speed and the size of the impeller. When it is desired to lift water to a considerable height, multi-stage pumps should be used.

Before selecting and installing a centrifugal pump, the following information should be collected.

1. Static suction lift or the vertical distance from the water level to the pump centre.
2. Frictional losses in the suction pipe and fittings.
3. Static delivery head, or the vertical distance from the centre of the pump to the highest point of the delivery pipe.
4. Frictional losses in the delivery pipe and fittings.

Selection of a centrifugal pump for a particular job is a matter for a specialist. The farmer who wants to purchase a pump should be asked to give the following information to the supplier or to the Village Level Worker.

1. The purpose for which the pump is required.
2. Whether water in the well is clean and at normal temperature.
3. The quantity of water required in gallons per hour.
4. The static suction lift. If the level of water fluctuates, the details of variation should be indicated.
5. General installation details.
6. Length of the pipe required.
7. The prime mover and the method of drive—flat belt, 'V' belt or direct coupling to an engine or motor.
8. Rough lay-out of the situation and any other special requirements of the farmer.

The firms supplying centrifugal pumps usually have complete data regarding the speed and the size of the pulleys of the engine and the pump, frictional losses in the pipes, hydraulic data, etc., and it is, therefore, best to refer the question of the selection of the pump to them along with the above information.

The trouble often experienced with the centrifugal pumps is that they fail to function owing to leakage in the foot-valves. This can be overcome by fitting a vacuum priming tank. The capacity of the tank should be four times that of the suction pipe. To get the pump to start, the tank is filled until water overflows down the suction pipe. The filler plug of the cap is then replaced and made air-tight. The pump is then started.

Where the water level fluctuates considerably, submerged centrifugal pumps worked by electric power have proved useful. These also are now being marketed in India.

Tube-wells

Wherever the soil is soft and the water level high, it is possible to construct tube-wells. Where there is a hard layer of stones, as in the Deccan plateau, it is not possible to construct tube-wells economically. Tube-well irrigation is particularly profitable in areas where electricity is available and where cash crops are grown.

There are three types of tube-wells.

1. ARTESIAN TUBE-WELLS: These tube-wells are so named because water flows automatically through them at pressure. Suitable strata for such tube-wells do not exist in most parts of India and hence they are not constructed in large numbers.

2. CAVITY TUBE-WELLS: Cavity tube-wells are bored through a layer of hard clay beneath which a layer of coarse sand forms a water reservoir through which water is pumped.

3. STRAINER TUBE-WELLS: These are constructed in clay soils, in which a strainer pipe, prepared from slotted brass tubes, tubes with holes and coir wrapped round them or tubes covered with a copper wire-netting welded on that, is used.

Tube-wells can be bored either by hand or by power-driven machines. The equipment for hand boring consists of a casing pipe and a sledger. The sledger is a pipe with a cutter end and a oneway valve. The sledge picks up the soil from below and makes a hole in which the casing pipe slides down. The power-driven machine works like an auger bit. The earth shavings come out due to the water which is pumped from inside the shaft. The simplest hand boring equipment costs about Rs. 200 to 300 while the power machine costs about Rs. 20,000 or more.

Chapter 13

PLANT PROTECTION EQUIPMENT

Plant protection implements include sprayers, dusters, seed dressers, flame throwers, bird scarers, etc. By their use farmers can protect their crops from harmful birds, insects and diseases. Pesticides as well as plant protection machines are now readily available in India and these machines are not very costly.

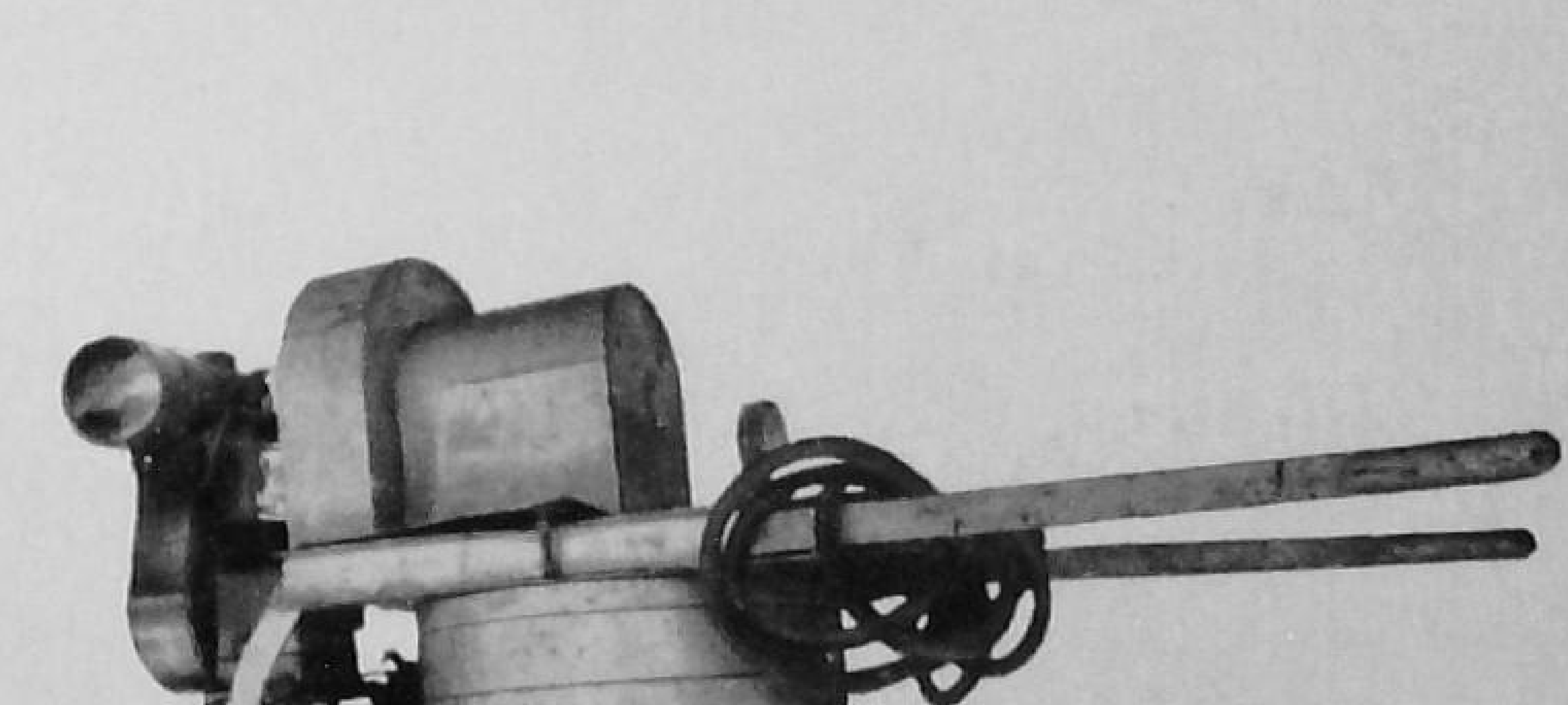
Dusters: A rotary hand duster, with a capacity of 8 to 10 lb., which can be used to dust trees and crops is now available. It is fitted with a regulator to control the flow of the insecticide dust, a breast plate and a belt for the operator. The mechanism consists of a fan worked by gears which picks up the dust from the container and throws it out of the spray nozzle.

Another small rotary hand duster with a Y-shaped coupling having two spray nozzles, and which can be easily carried by the operator is also available. Its capacity is about 8 to 10 lb., and the dusting can be regulated from 5 to 20 lb. per acre.

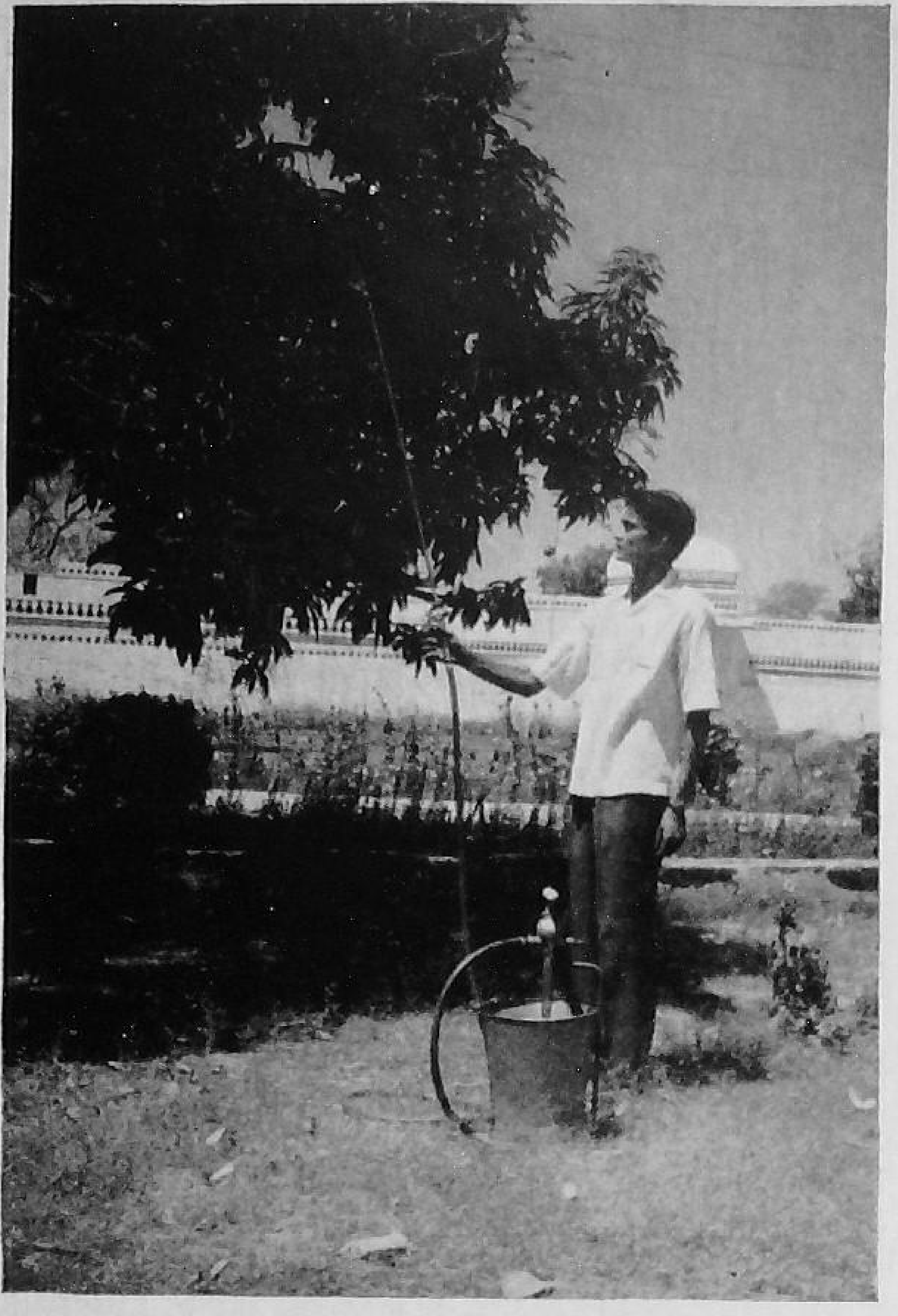
For small farms or gardens, plunger type dusters are useful. Usually, free floating plungers are used in them and their capacity is about 1 lb. These dusters can be fitted with an adjustable nozzle by means of which dusting can be done in all directions.

Sprayers: Hand compression sprayers have brass containers or tanks manufactured from brass alloy, heavy gauge high tension sheets. They are welded and are tested to withstand a high pressure of 120 to 200 lb. per square inch. Their capacity ranges from one to five gallons. At the top, there is a billing bung and the sprayer is fitted with an adjustable carrying strap. A D-shaped handle and a quick action locking device are also provided. The accessories include a delivery hose, a trigger shut-off cock, a hollow cone mist spray nozzle and a filling funnel.

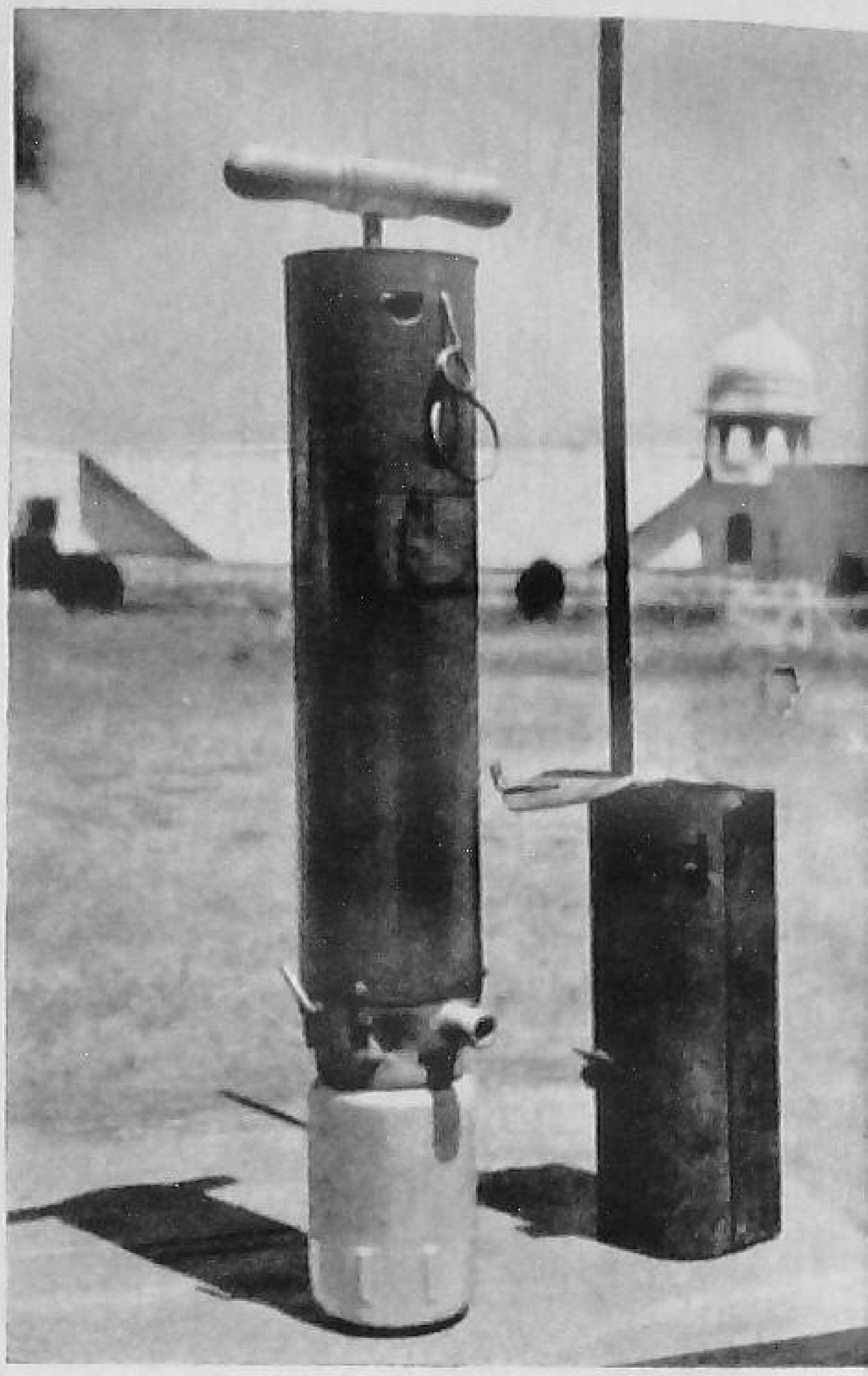
A Hand Sprayer



A Power Sprayer

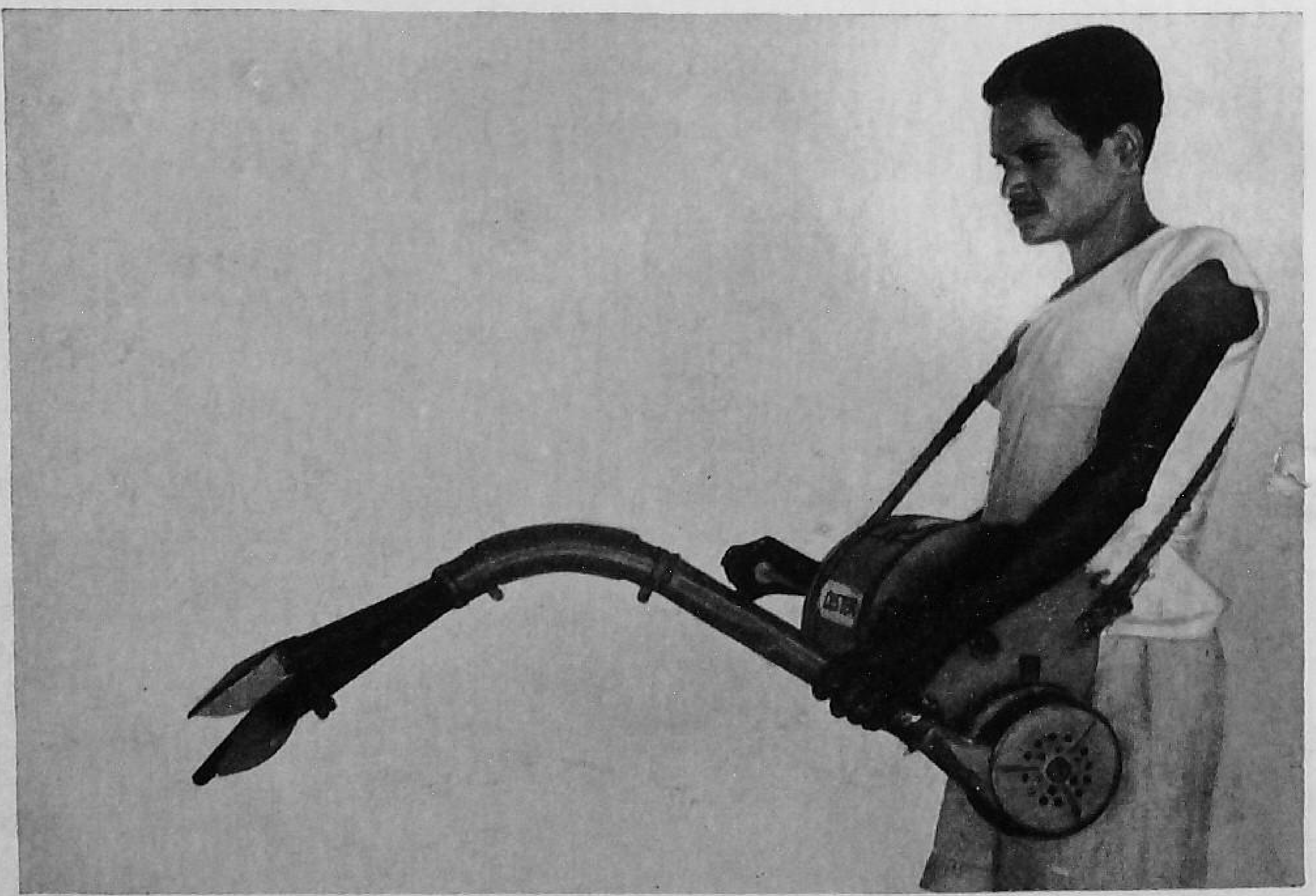


Spraying Pesticide with a Bucket Spray Pump



A Gas Pump (left) and a Nozzle of a Flame Thrower

A Duster with Y-shaped Nozzle



Bucket spray pumps manufactured from seamless brass tubing have a strainer at the suction end, a delivery hole fitted with a trigger control shut-off cock and a hollow cone mist spray nozzle. Shut-off cocks, spray lances and spray nozzles which can be used with the pumps are available in a variety of designs.

Some sprayers have a smoll cylinder, a plunger fixed on a wooden plate and a pressure vessel. The pressure vessel gives a constant and uniform spray.

Power sprayers worked by small oil engines can cover a large area.

FLAME GUNS: For killing insects like locusts, flame throwers or flame guns have proved very useful. A flame thrower or a flame gun can be fixed to a pressure type sprayer. High pressure oil and explosion-proof synthetic chemicals should be used in them. The flame can be controlled by means of a valve.

GAS PUMP: A gas pump is available for killing rats. It introduces poisonous gas in to the rodent holes. As this gas is very poisonous, great care should be taken in using it.

SEED DRESSER: Before the seed is sown, it is advisable to dress it with a chemical to kill all the insects and germs. Seed dressers are available for about Rs. 60 each. However, a simple seed dresser that costs hardly Rs. 3 can also be made. It consists of a standard size kerosene tin through which a round steel axle is fixed. The seed and the chemical are placed together in the tin and it is rotated for about ten to 15 minutes.

Chapter 14

HORTICULTURAL IMPLEMENTS AND GARDEN TOOLS

Gardening is both a pleasant hobby and a profitable profession. A variety of specialised hand-tools are available for this purpose. Most of these are simple and small. Village Level Workers should learn the correct way of using them.

A brief description of the uses of important garden tools is given below.

1. Garden trowels are used for scraping the soil and cost about Rs. 4 each. They are usually made of an aluminium alloy.

2. Transplanting trowels have a pointed end and are used for digging seedlings. They cost about Rs. 4 each.

3. Garden forks have four prongs and cost about Rs. 4 each.

4. Hand syringes are used for spraying insecticides.

5. Garden rakes are used for preparing the nursery and beds and may have ten to fourteen teeth. Their cost ranges from Rs. 3.75 to 4.75.

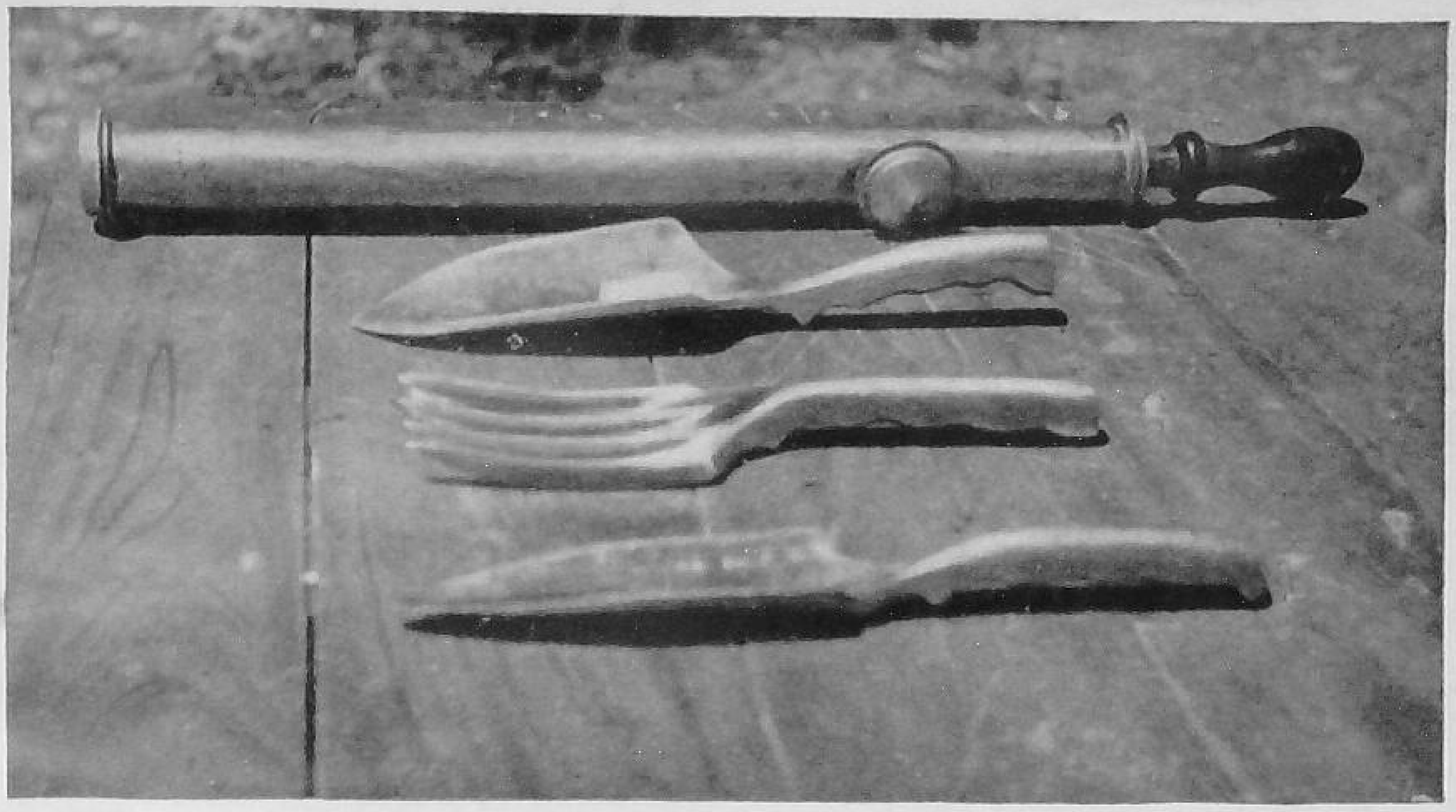
6. Singh hand hoes cost about Rs. 3.50 each and are used for weeding and scraping the soil. They may have three to five prongs.

7. Kodali forks are used for digging the soil and cost about Rs. 5.50.

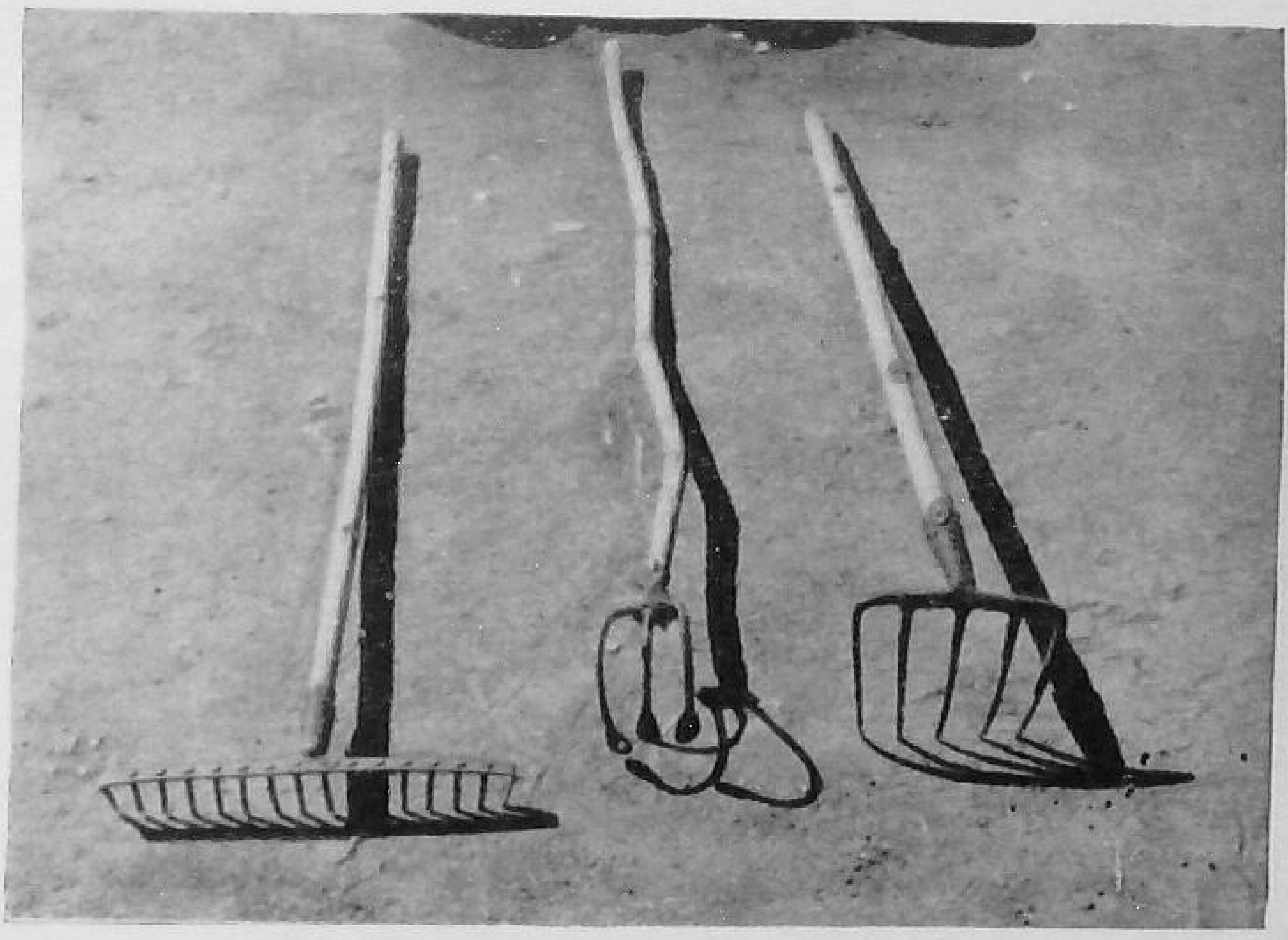
8. Digging spades (Western type) are used for digging and spreading the soil. They cost about Rs. 6 each.

9. Digging forks may have either a D-shaped or a T-shaped handle. They are worked as a lever and the weight of the worker is made use of. This gives the forks a good mechanical advantage. They are very useful for digging gardens.

10. Spades or phawrahs are used for collecting soil, for chopping grass and for many other purposes like unloading



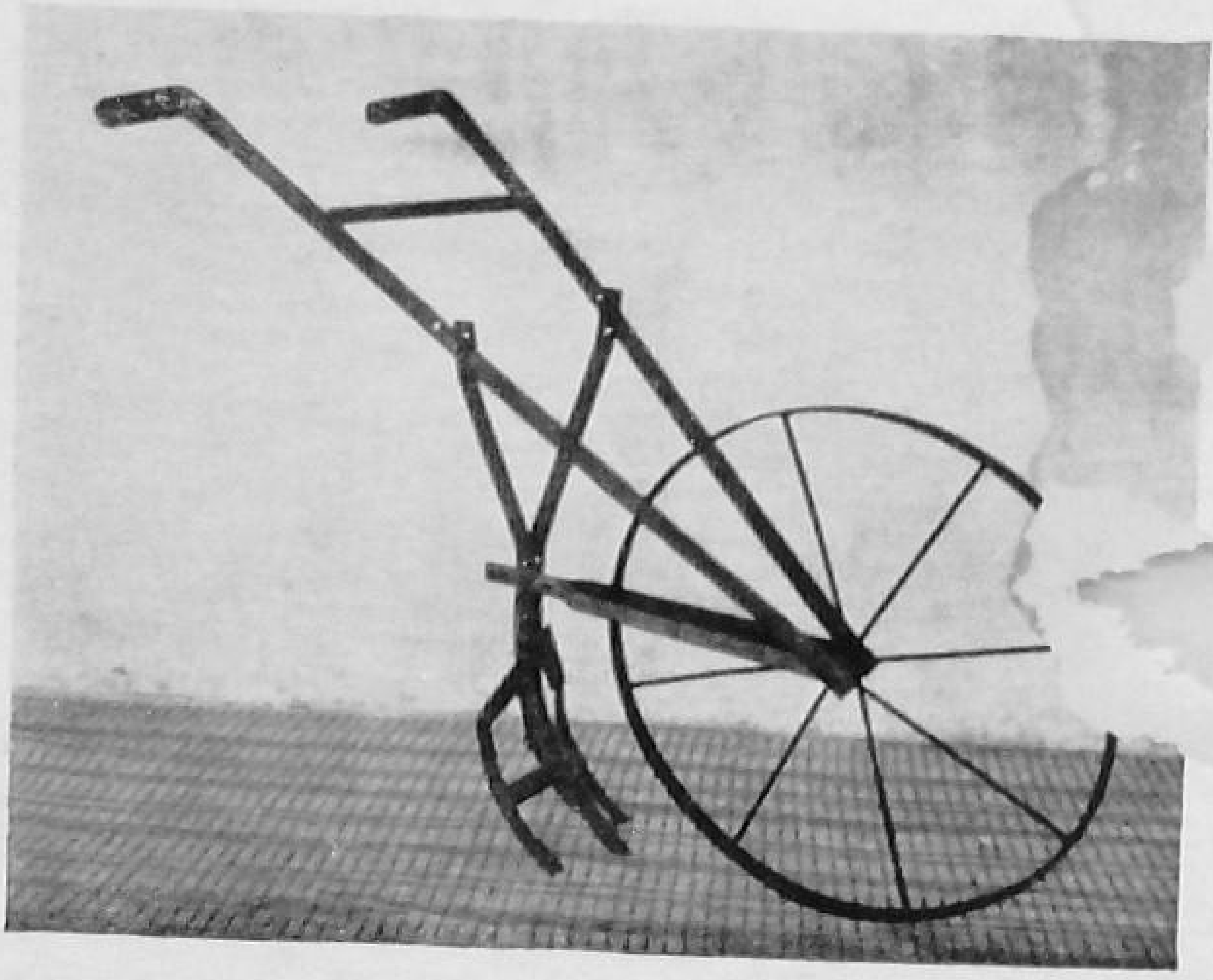
A Hand Syringe (top), Trowels and a Fork



(Left to right) A Garden Rake, a Singh Hand Hoe and a Kodali Fork

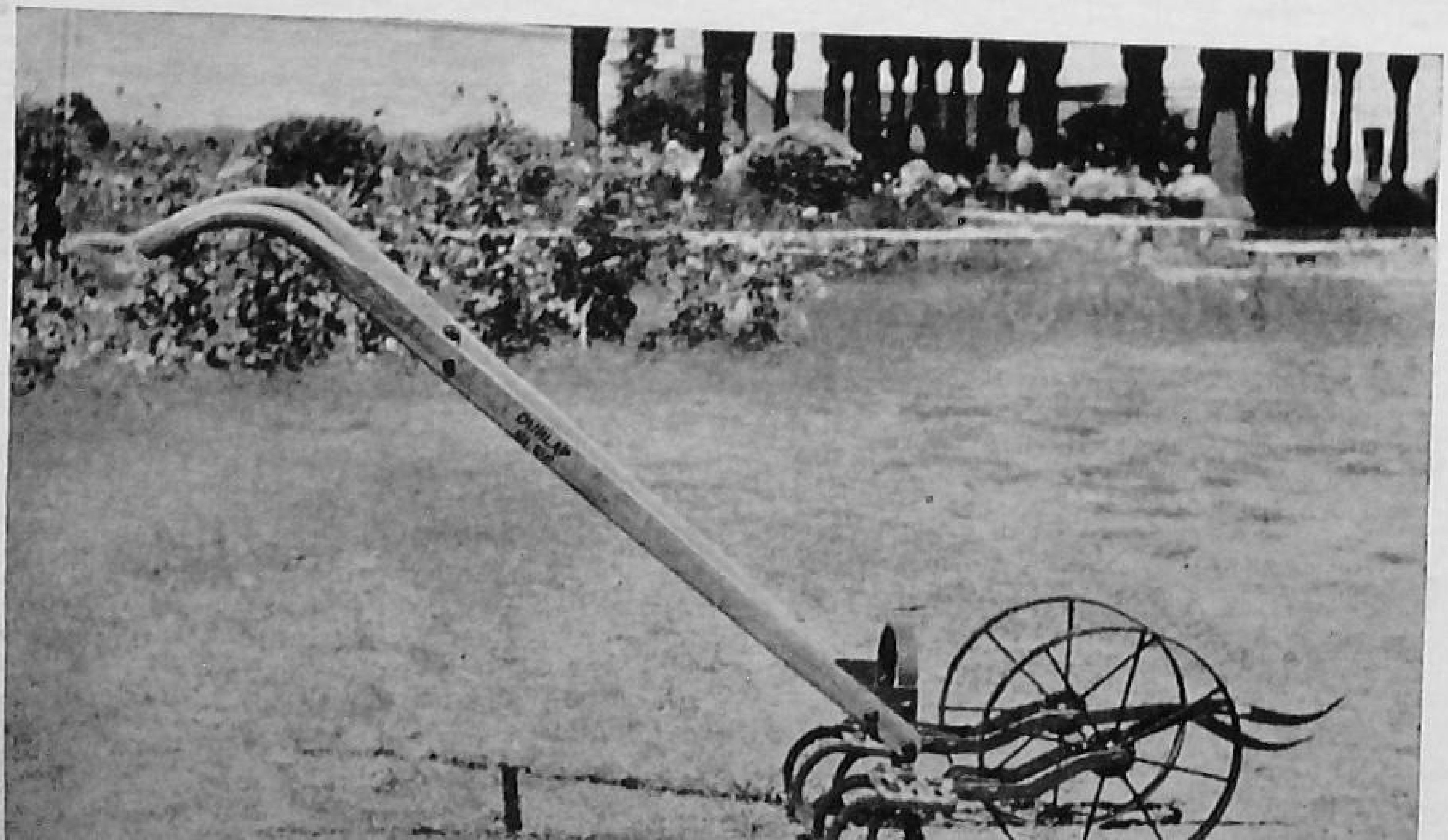
(Left to right) A Western Type Spade, a Digging Fork, a Phawra and a Pickaxe

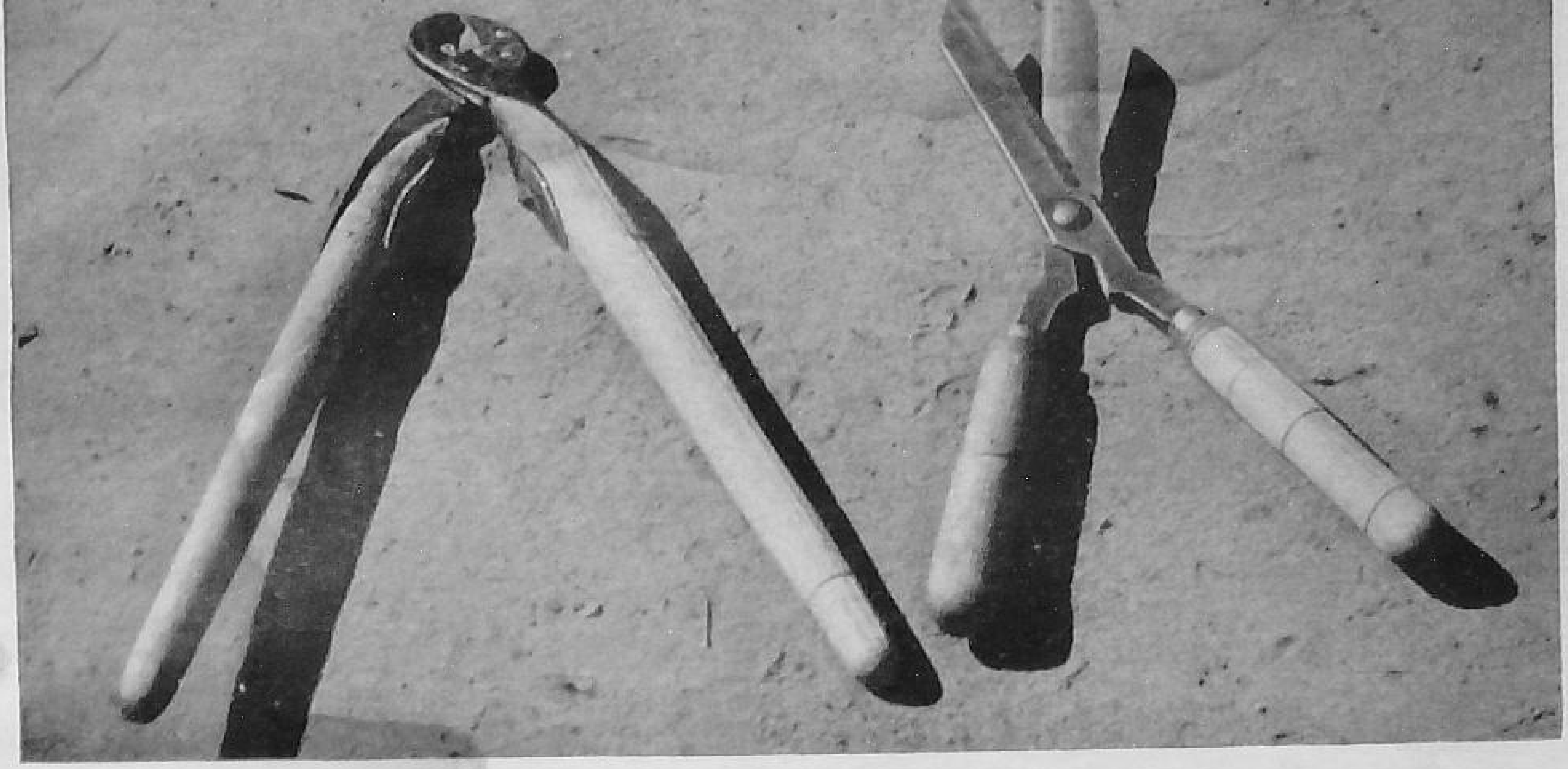
(Left to right)
A Single Pointed Pickaxe, a Hand Rake and an Axe



A One-wheel Hand Hoe

A Two-wheel Hand Cultivator



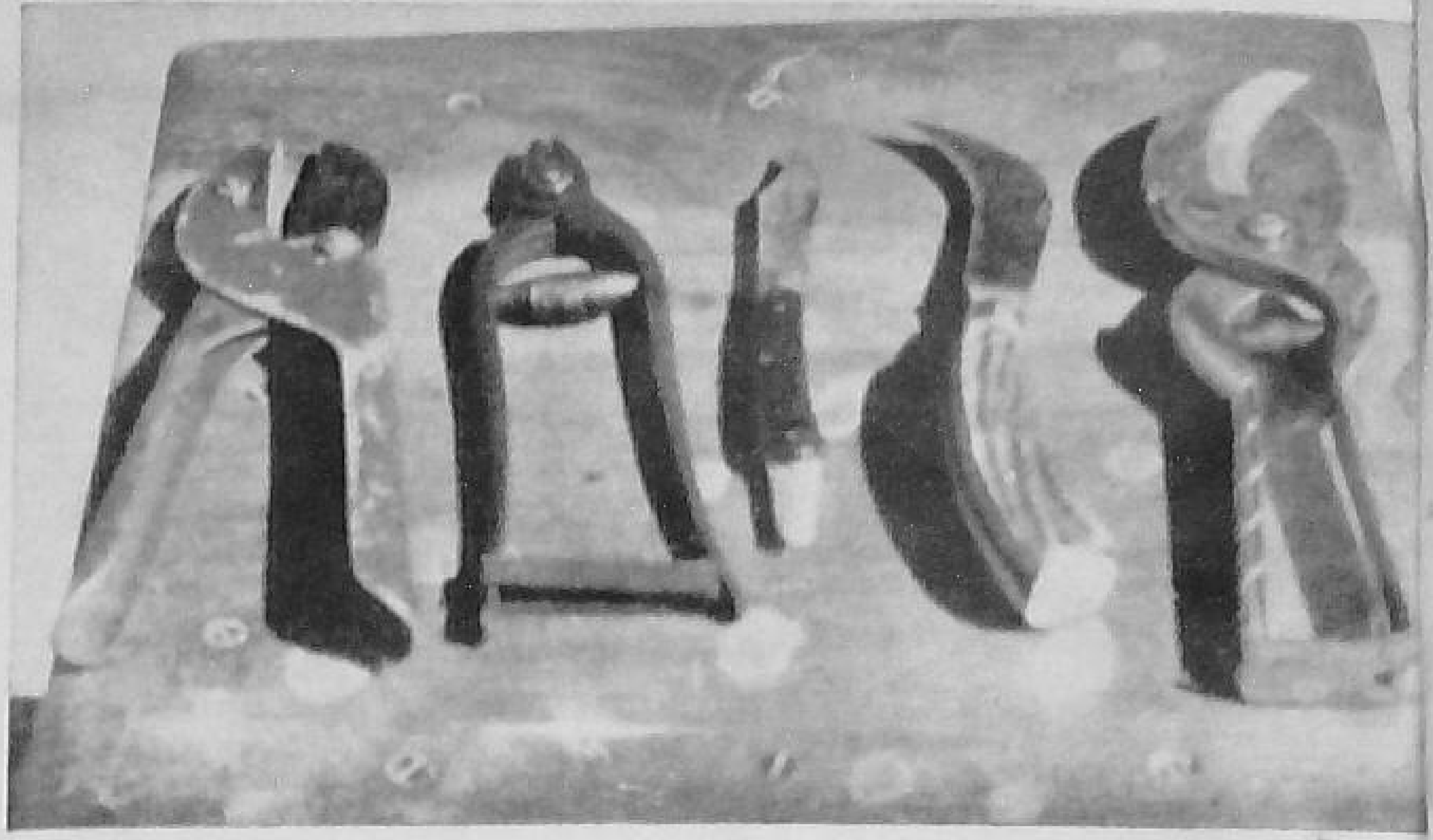


Forester's Shears (left) and Garden Shears

A Hand-sowing Machine

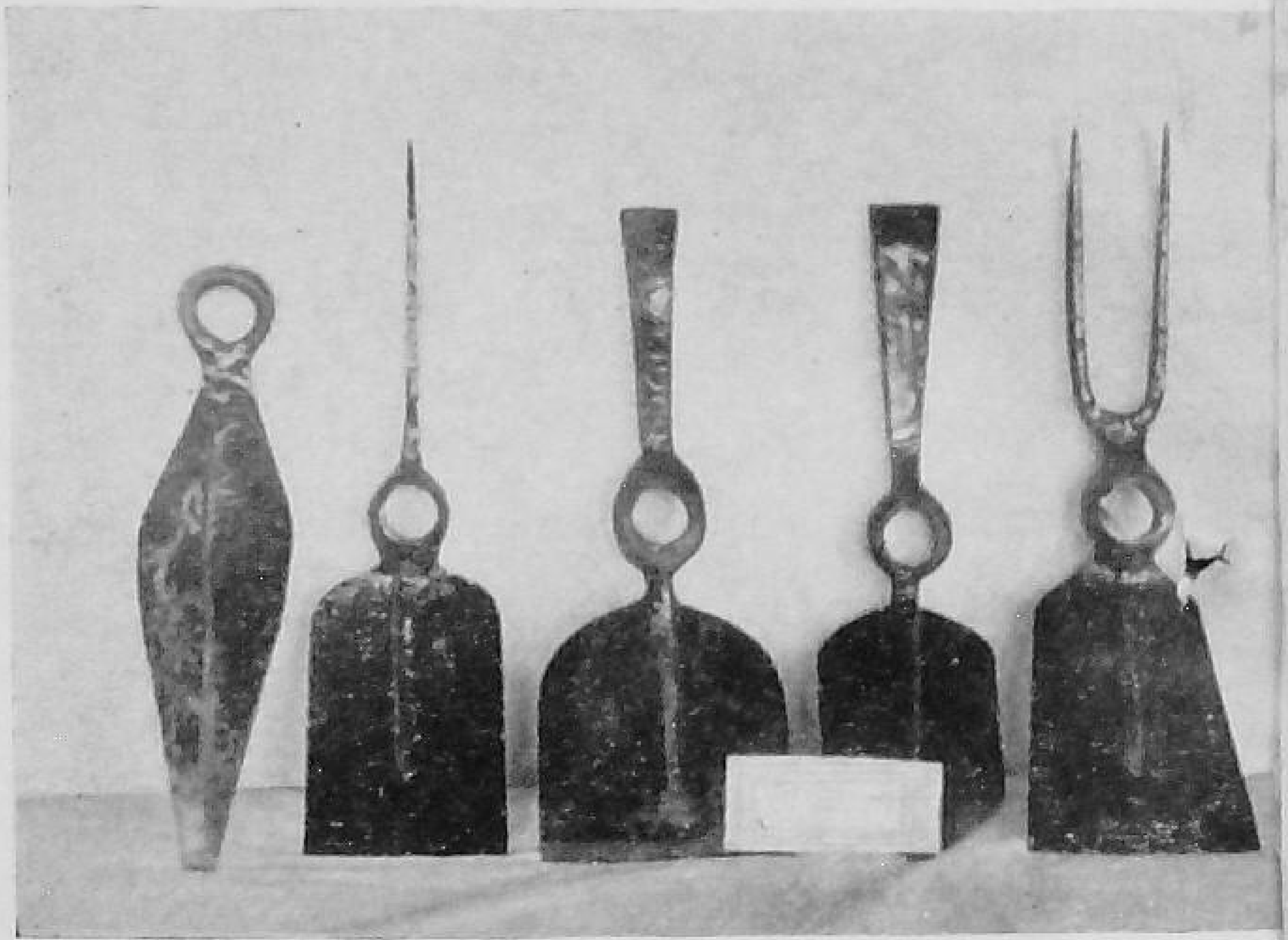
A Wheel Barrow

Secateurs (first and second from left and extreme right), a Budding Knife (centre) and a Pruning Knife



Pruning Saws, Sickles, a Tape and a Foot-rule

Spades



Khurpies

manure from a bullock cart. They cost about Rs. 2 each.

11. DOUBLE-POINTED PICKAXES weigh approximately 6 lb. each and cost about Rs. 5 each. They are used for digging hard soil.

12. SINGLE-POINTED PICKAXES cost about Rs. 3.

13. AXES cost about Rs. 2 each. They are used for cutting wood.

14. ONE-WHEEL HAND HOES are light implements having a ground wheel in the front. Their soil working parts can be changed as desired. They are used for intercultivation of garden crops.

15. TWO-WHEEL HAND CULTIVATORS have more elaborate accessories than the one-wheel hand hoe. These consist of a small plough, a ridger and cultivator shovels. This cultivator can be worked by one man in-between rows of plants or astride the plants.

16. HAND-SOWING MACHINES can be used in combination with the one or two-wheeled hand cultivators for sowing vegetable seeds. There is an arrangement for adjusting the seed-rate and also for marking the lines. The seed-dropping mechanism is usually a roller with notches or depressions on its periphery.

17. WHEEL BARROWS are very useful for transporting fertilizers, manure, soil and seedlings. They have a front wheel and two back stays with a handle. Their capacity is usually three cubic feet and they cost about Rs. 70 to 80 each. Their trays are prepared from sheet metal.

18. GARDEN SHEARS have a straight or wavy edge and are used for pruning hedges. The wavy edge helps in securing one or more sturdy twigs at a time. The edge should be sharp so that there is no squeezing or chewing. A safety screw is usually provided to prevent the blades from getting out of adjustment. The blades are prepared from fine quality steel. The approximate cost of a garden shear is Rs. 16.

19. FORESTER'S SHEARS have long handles and are used for cutting fairly big twigs.

20. PRUNING SECATEURS are prepared out of well tempered steel. They cost about Rs. 10 each.

21. Budding knives have a bone scraper at one end and cost about Rs. 6 each. The knives are prepared from good quality steel and should always be kept sharp.

22. Pruning knives have handles of stag horn or wood. They cost about Rs. 6 each. A pruning knife should be well tempered and bolstered in brass.

23. Khurpies are of various kinds having two to three prongs and straight or curved edges. These are used for digging weeds and scraping soil between lines of plants and around the plants. Their cost ranges from 50 to 75 naye paise.

24. Spade-cum-diggers of various designs are available. They are useful multipurpose implements for digging and levelling soil and cost between Rs. 2 and 3 each.

25. Pruning saws are used when the twigs or branches are too thick to cut with pruning shears or secateurs. They cost approximately Rs. 8 each.

26. Curved sickles are commonly used in India for harvesting garden crops. They cost about 75 naye paise each.

27. Tapes and foot-rules are useful accessories. They are used for laying out the garden.

28. Water cans used in gardening are prepared from galvanised sheet metal and may be round or oval in shape. An improved water can, with a long spout and a handle so fixed that it is more convenient for carrying and emptying it, is available. At the end of the spout a 'rose' with a number of small holes is provided. This may be a permanently fixed one or removable. The usual capacity of a can is two gallons and its cost ranges from Rs. 12 to 14.

29. Lawn-mowers are used for trimming grass to a particular height. The models which can be worked by a man usually have a side-wheel drive obtained by using gears. At the back, rollers for pressing the grass are provided. The cutting mechanism consists of a specially shaped knife. The cost of the mowers ranges from Rs. 100 to 240 each according to the size of the cut, which ranges from 12″ to 16″.

30. Dutch hoes have a 4″ long, straight or V-shaped edge. They cost about Rs. 4 each.

A Lawn-mower

An Oval-shaped Water Can with a Balanced Handle

Milk Cans

A Gerber Centrifuge (right) with Milk Testing Apparatus

Milk Bottles (left), a Capping Machine (second from right) and a Sealing Punch (extreme right)

31. CHUHA RAMBAS are commonly used in nurseries in the Punjab to lift seedlings from the soil. Slits are made in the soil around the seedling and it is lifted by the implement without any damage to its roots. They cost about Rs. 1.50 each.

Chapter 15

DAIRYING AND ANIMAL HUSBANDRY EQUIPMENT

The equipment described in this chapter is suitable mainly for small dairies and is not meant for big dairies supplying milk to urban areas.

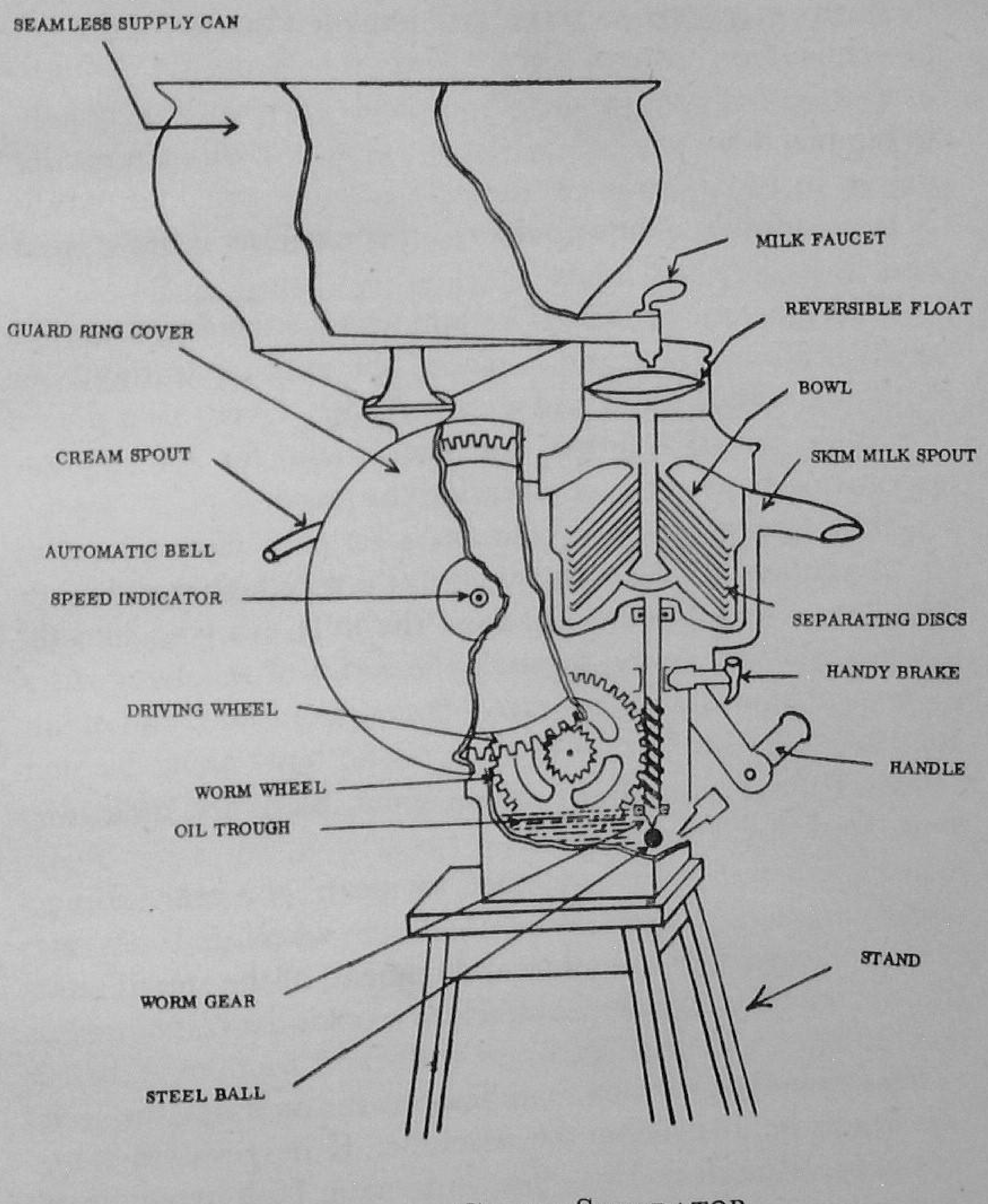
Dairy equipment must be handled cleanly as milk products are spoilt very easily. Such equipment must be manufactured out of good quality metal and must be well maintained. Excepting the cream separators, the rest of the dairy equipment is now manufactured in India.

Milking Cans or Utensils: Milking cans are usually prepared out of stainless steel or aluminium and are freely available in different sizes and shapes.

The design of any utensil in which milk is stored or carried should be such that the utensil can be cleaned easily and thoroughly. The approximate cost of a big aluminium milking can is about Rs. 25, and that of a stainless steel can, about Rs. 100.

Milk Bottles: After pasteurisation, milk is bottled for consumption. The bottles may be of different sizes, their capacity ranging from ½ to 2 lb. The bottles are capped by a bottle capping machine. Where milk is sold in big cans, the cans are sealed with a small sealing punch. The approximate cost of a bottle capping machine is about Rs. 10 and of a can sealing machine about Rs. 6.

Centrifugal Fat Testing Machines: As soon as milk is brought to milk collecting centres of big dairies, it is tested for its fat percentage and the farmer is paid accordingly. The Gerber centrifugal machine is used for this purpose. It consists of a rotary disc covered with a lid in which six to eight graduated test-tubes can be fixed. Measured milk samples along with chemicals are placed inside the tubes and are rotated at a very high speed of over 1,000 revolutions a minute. The centrifugal force thus produced, separates fat



PARTS OF A CREAM SEPARATOR

globules from milk. These fat globules accumulate at the graduated end of the tube. The more the fat in the milk, the greater the space the fat globules occupy.

CREAM SEPARATORS: Cream is separated from milk with the help of a cream separator, which also works on the principle of centrifugal force. Cream separators are available in a variety of sizes ranging from small ones worked by hand to big machines worked by electric motors or oil engines. For dairies in India, however, the Alfa-Laval 60 cream separator is most suitable. The capacity of this machine is between 30 and 50 gallons per hour.

The machine consists of a stand which is fixed to a wooden table and over the stand is placed the milk separating bowl with a skim milk spout and a cream spout. Over this is placed the milk can. The gears and the handle for rotating the separating bowl are located inside the stand.

The separating bowl contains a series of discs separated by thin space. These discs revolve at a very high speed when the handle is rotated. Milk from the milk can goes into the bowl and then passes through the series of revolving discs. The centrifugal force separates cream from milk and cream moves to the uppermost portion of the bowl along its stem and is let out through the cream spout. Skimmed milk is let out through the milk spout.

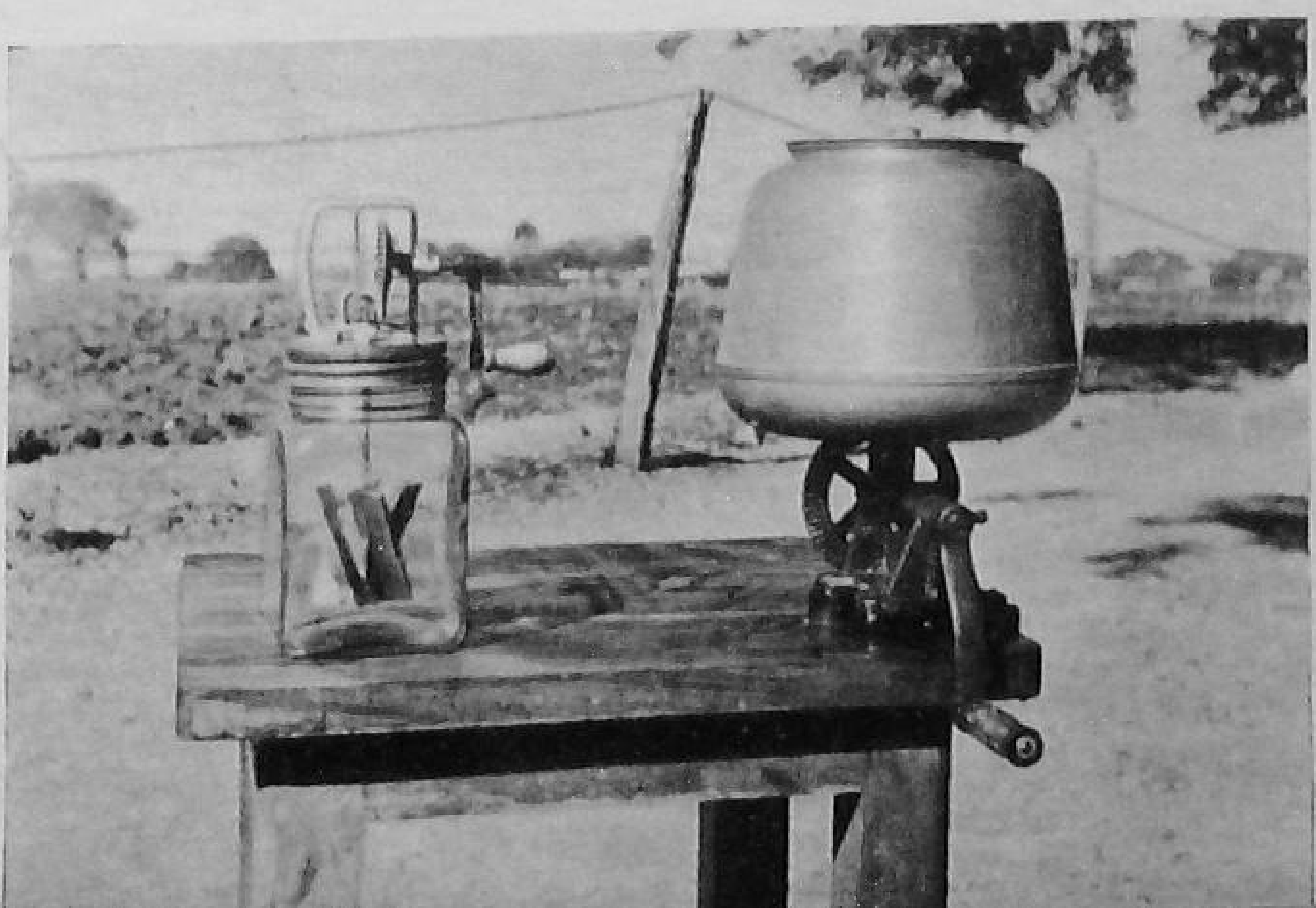
The revolutions are obtained by means of a gear arrangement of two helical gears and one worm wheel. Ball-bearings are fixed wherever necessary and one end of the spindle rests on a jewel point or a steel ball. Here jewel is used because it is the hardest substance and can withstand friction. A bell is fixed inside the gear box to indicate to the operator the speed at which he is driving the machine. If he revolves it too speedily, the bell gives a ring. Automatic flash arrangement for lubrication is provided inside the casing of the machine. The machine is so oiled that oil does not come into contact with milk or cream, otherwise they get an oily smell.

It is important to note that the bowl of the cream separator should be well balanced so as to obtain maximum efficiency. After using the cream separator for a period of two to

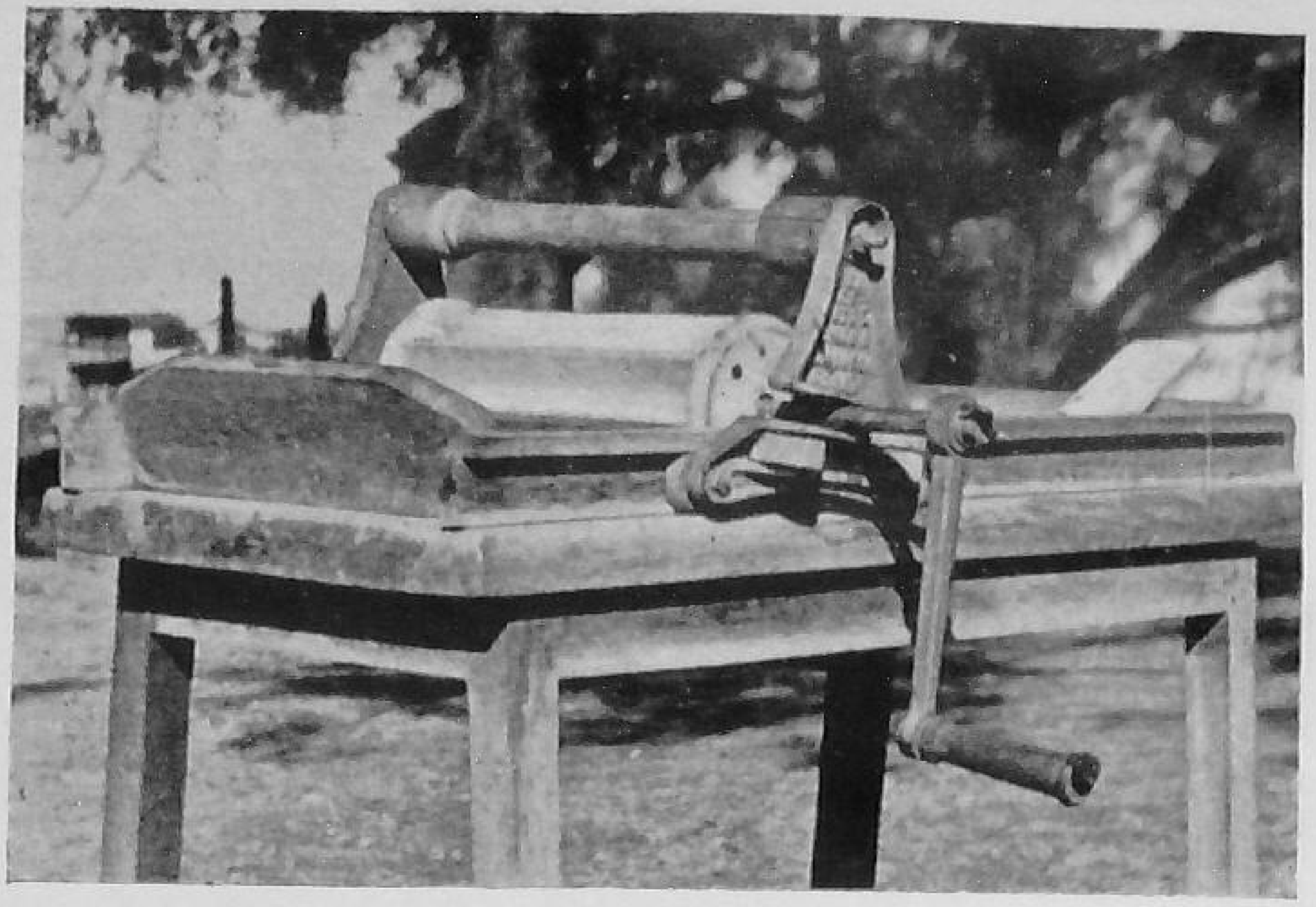
A Cream Separator Dismantled to Show its Parts

A Cream Separator

A Household Glass Butter Churn (left) and a Small Dairy Type Butter Churn

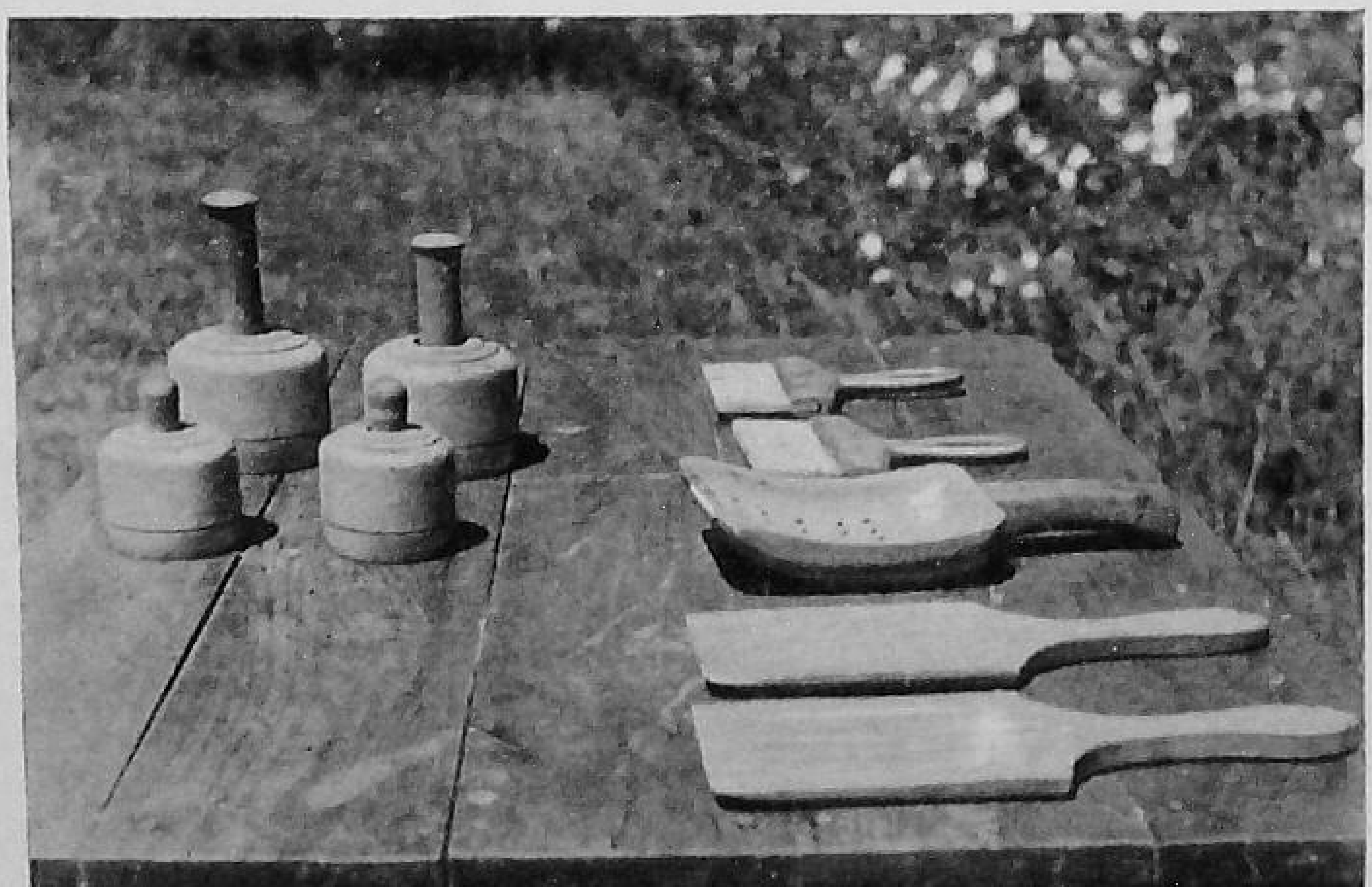


A Butter Worker



A Wooden Barrel Butter Churn

Butter Moulds (left), Squeegees (right top), a Butter Scoop (right centre) and Scotch Hands (right foreground)



three years, this balance should be got tested from the manufacturer's trained operator. The cost of a milk separator ranges from Rs. 150 to 300.

Butter Churns: After cream is subjected to the action of bacteria and is made sour, it is placed inside a butter churn with required amount of hot water. The butter churn is then revolved till butter gets separated from buttermilk. For this purpose butter churns of various sizes, manufactured from steel, glass or wood, are used.

A small household type butter churn prepared out of a glass jar, has a pair of bevel gears with the help of which its fan is rotated.

The wooden barrel-shaped butter churn is suitable for big dairies. The barrel is mounted on a stand on an axle. The lid of this butter churn is so fixed that there is no possibility of its getting loosened. Before use, the churn is soaked in water so that all the crevices and cracks in the wood get filled in by its expansion. At the bottom of the barrel, a hole is provided to take out buttermilk. The axle of the barrel is provided with bush-bearings or ball-bearings.

Butter Worker and Accessories: After taking out butter from the churn it is put through a butter worker for squeezing out buttermilk. The butter worker has a table-like construction on which a trough is fixed and inside the trough there is a grooved wooden roller which presses butter and squeezes out buttermilk. The approximate cost of a butter worker is Rs. 60.

While working the butter worker this way, a pair of Scotch hands is used for handling butter so that it remains untouched by hand. A pair of Scotch hands approximately costs Rs. 4. A cream squeegee costing about Rs. 2.50 is used for collecting butter particles, and a butter scoop costing about Rs. 6.50 is utilised for collecting butter from the churn. The scoop has holes through which buttermilk flows out and only butter remains at the bottom. After squeezing out buttermilk, butter is put in moulds and tablets of required size are prepared. A set of such moulds costs about Rs. 5.

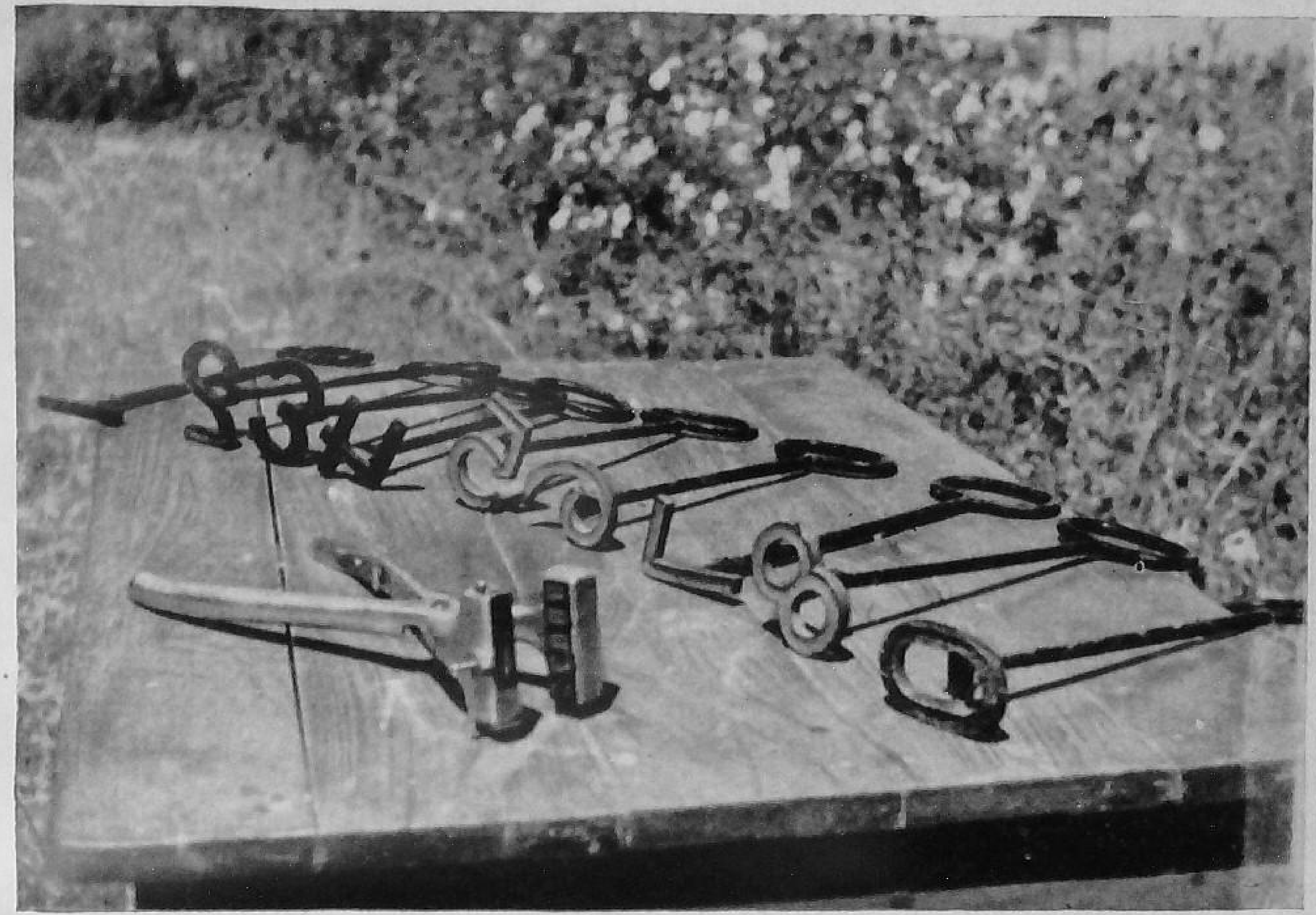
Animal Husbandry Tools: Certain tools are required for

branding or tattooing cattle. A cold branding set with eight pieces costs about Rs. 54.

The tattooing tool which is used for tattooing calves, sheep, etc., costs Rs. 195 approximately.

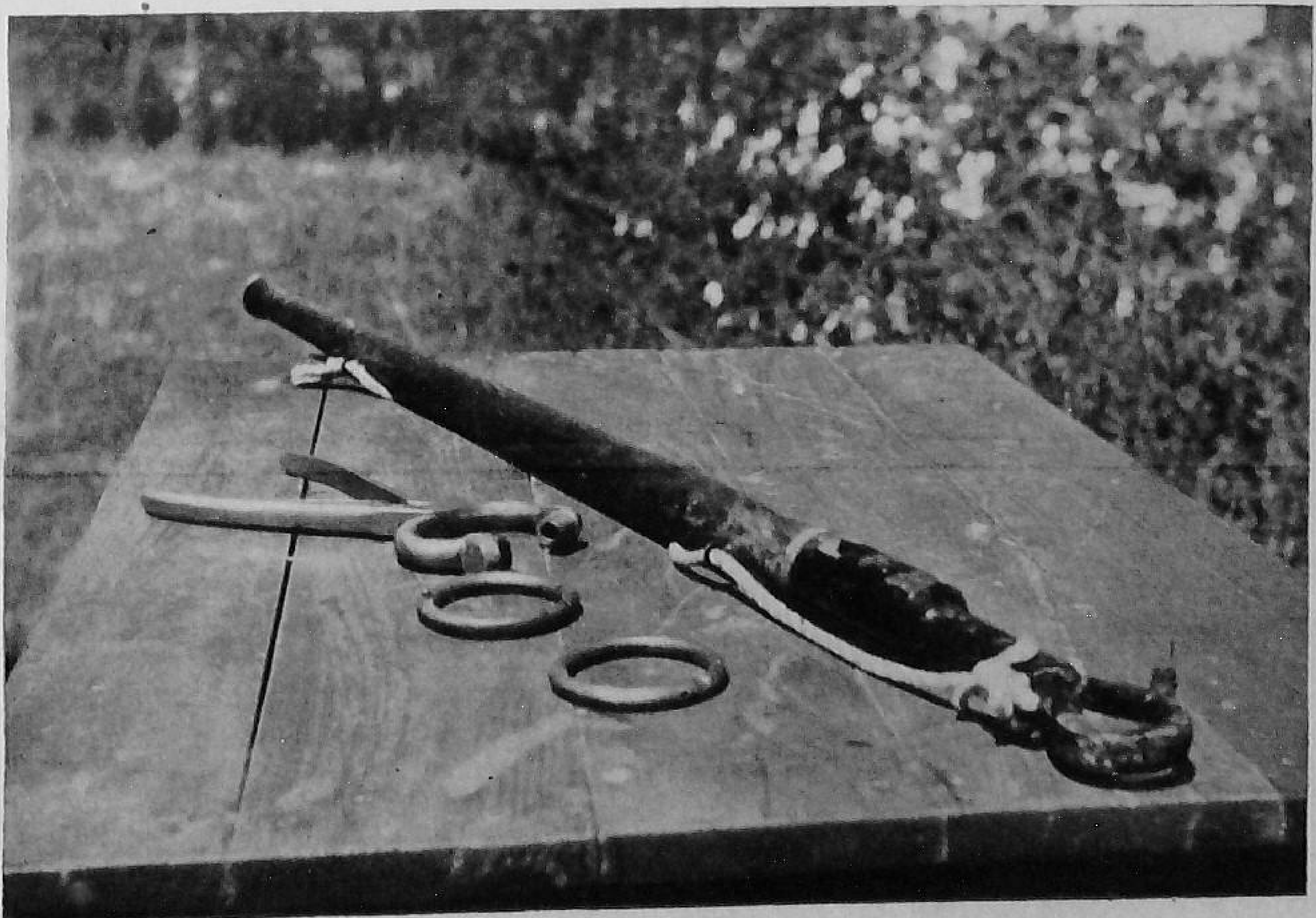
Bull-rings and bull-rods are used to control the bull. On cattle breeding farms these small instruments prove very useful.

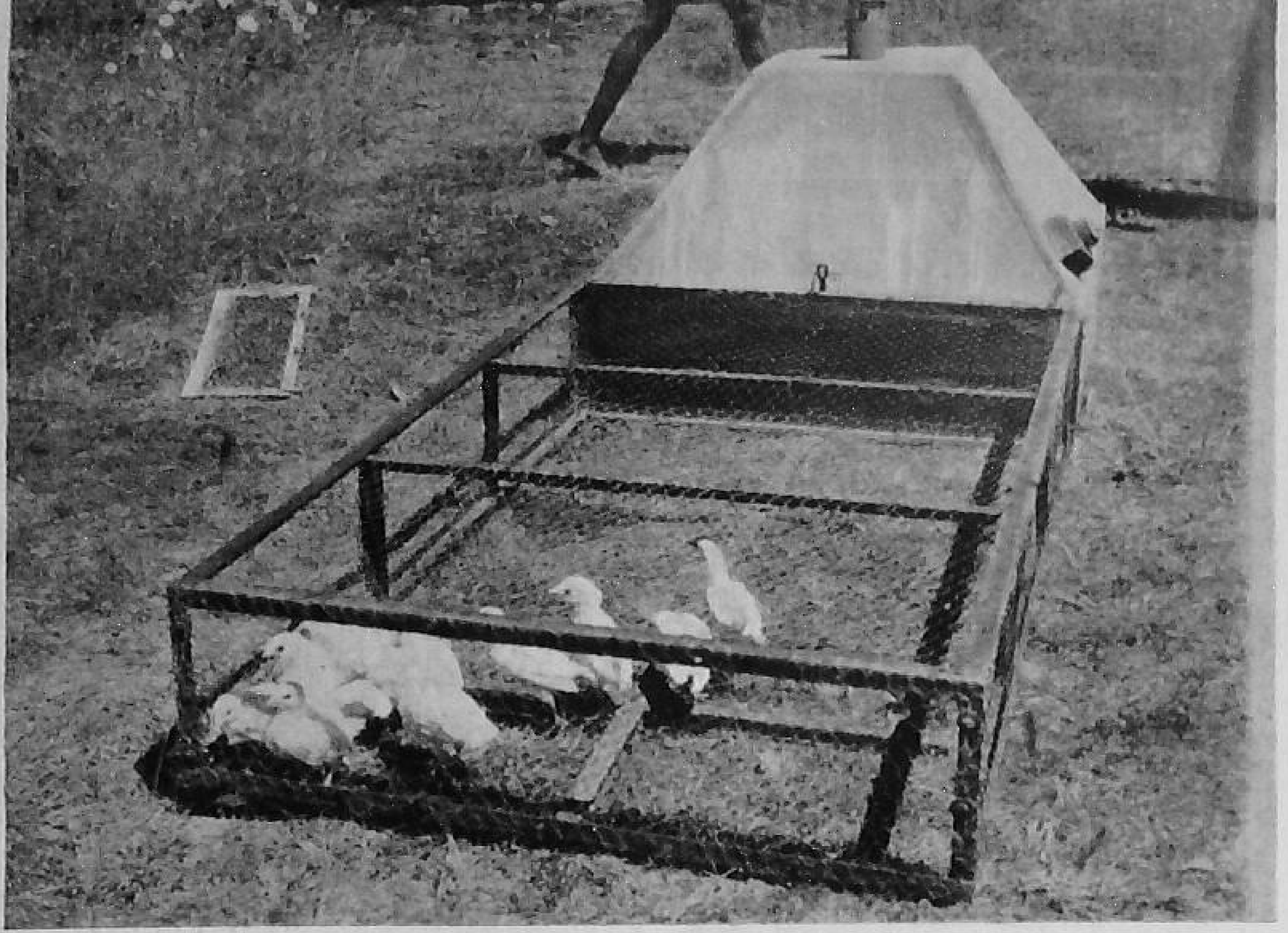
In all modern dairies, instead of ropes and chains a stanchion is used for tying cattle because it is more comfortable for animals and there is no danger of their getting out. It allows the animal to move its head to and fro, up and down, and also allows it to rest or lie down. The approximate cost of a stanchion is Rs. 20.



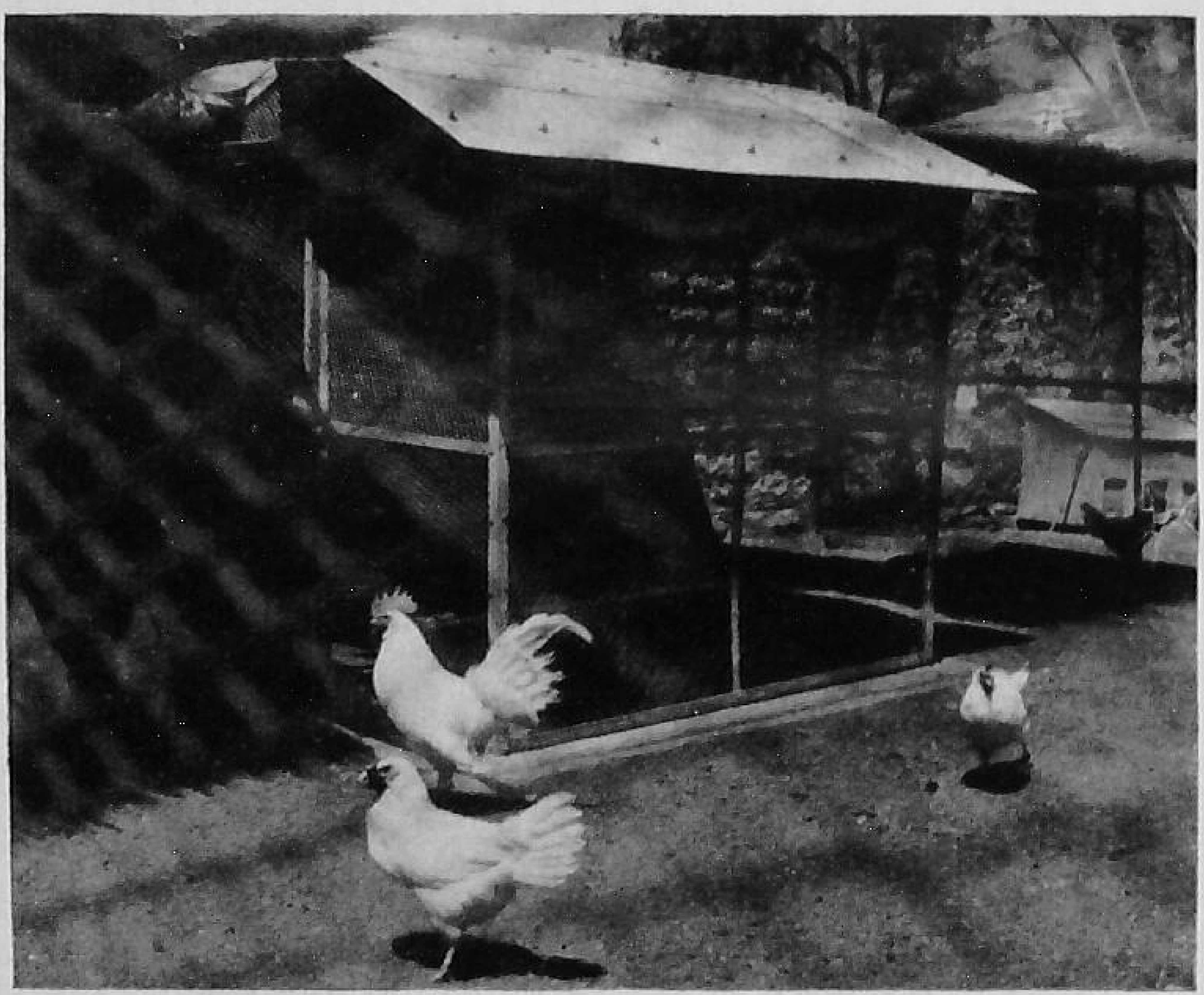
A Tattooing Tool (left) and a Cold Branding Set

A Punch (left top), Bull-rings (left bottom) and a Bull-rod (right)

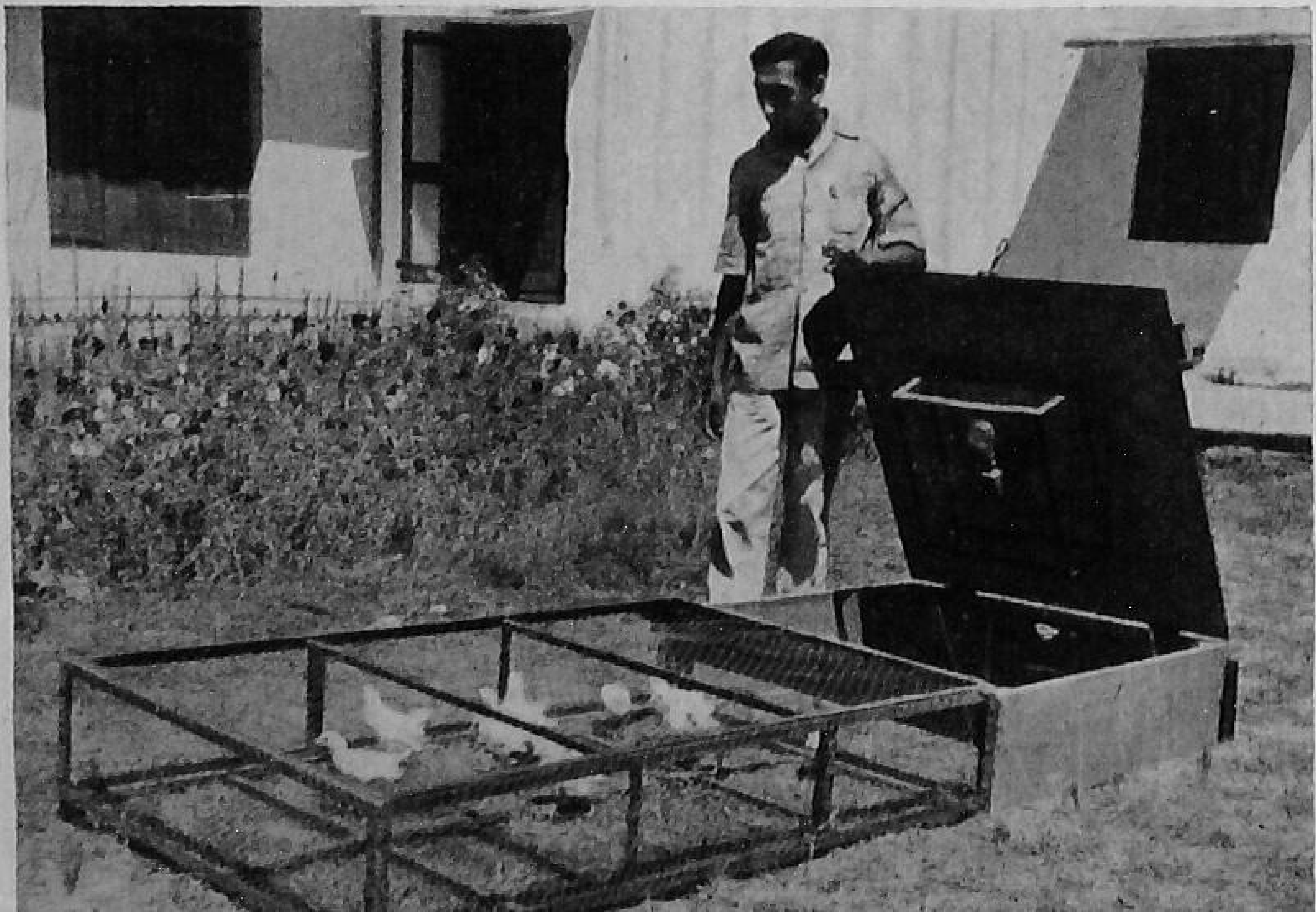




An Electrical Foster Mother with a Wire-netting Run



An Ideal Poultry House



Bulbs Provide Heat in this Foster Mother

Chapter 16

POULTRY EQUIPMENT

Poultry can be developed as a profitable side industry or as a full-scale cottage industry. In areas around big cities and towns there is quite a good demand for eggs. Poultry also does not require a large investment and can be kept by farmers without much trouble if they understand the technique and follow it properly. Poultry also fits into the farm programme very well. The following equipment is essential for successful poultry farming.

Poultry House: The purpose of providing proper housing for birds is to give them protection and keep them comfortable with a view to making them efficient egg producers. In extreme hot or cold weather, this efficiency of theirs is reduced. Chickens have no sweat glands to assist in keeping their body cool. In cold weather also, much of the energy is wasted by birds to conserve body heat instead of diverting it to the production of eggs.

A poultry house should provide proper environment for birds. It should be located on a site that is well drained and is at a slightly higher level than the surrounding area. Air circulation also should be satisfactory. The type of the house to be built will depend on the number of birds and the economic condition of the farmer. The roof of a poultry house may be shed type or gable type. Gable roofs slope to the front and the rear from the centre of the house. It is convenient for the attendant to work in this type of poultry house. In some places the gable roof is filled with straw to obtain insulation. An ideal poultry house for Indian conditions has cement asbestos sheet roofing and expanded metal screen on the sides. The roof is lined from the inside with burlap for insulation. The yard in which the poultry house is located is surrounded by a wire-netting fence. Inside the poultry house, elevated wooden battens are fixed so that birds can stand on them and rest.

Foster Mothers or Brooders: One of the best tests of a good poultryman is his ability to raise chickens. This could be done artificially by use of brooders or foster mothers. The heat for brooding may be supplied by burning wood, grass or by electricity. Electric foster mothers are clean and efficient. Some models of electric brooders are provided with a kerosene lamp in case electricity fails.

The foster mother is fixed with a wire-netting run or a sunporch. In order to ensure that all the birds take advantage of this run, they should be fed and watered in it or driven into it regularly at least once a day for about half an hour.

The bulb inside is protected by a wire-netting. The foster mother proper is made from galvanised sheet metal. For ventilation, a small chimney is also provided. The cost of a foster mother comes to about Rs. 50.

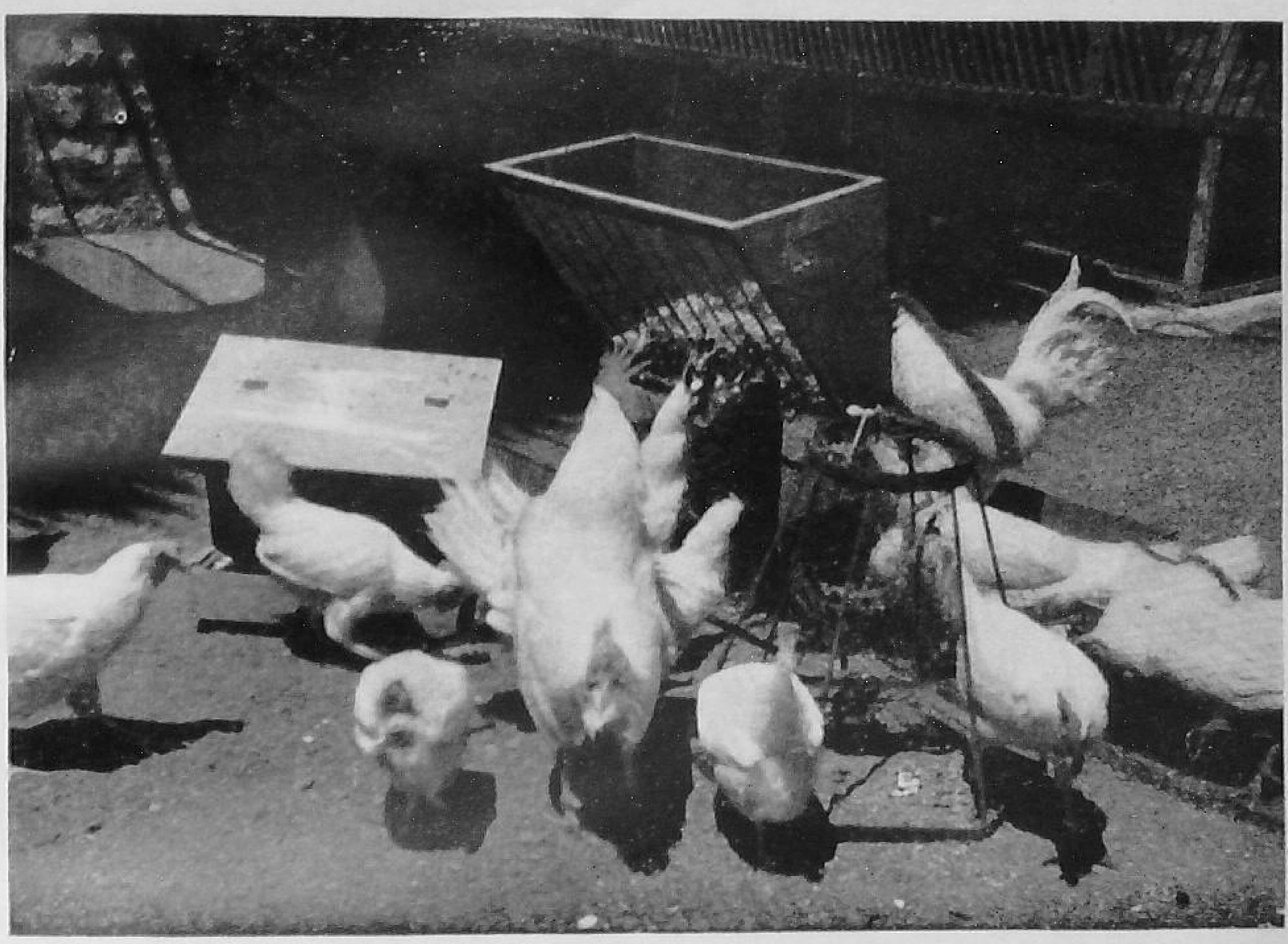
Poultry Feeding Equipment: The poultry feed consists of whole grains, crushed grains or pellets.

For feeding grain, a grain hopper is used and a mash trough is used for feeding mash. The cost of the grain hopper comes to about Rs. 15 and that of the mash feeding trough Rs. 2. For feeding shell and grit to poultry, a shell, grit and coal hopper costing Rs. 5 is used. By using hoppers for feeding, the food is made available to birds all the time.

Green silage and fresh cut grass have become popular as poultry feeds, especially for the breeding stock. An adult green leaf feeder costs about Rs. 3.50. It has two hooks by which it can be hung on the sidewall of the poultry yard. A chicken feeder costing about Rs. 5 for feeding foliage to the chickens is also available.

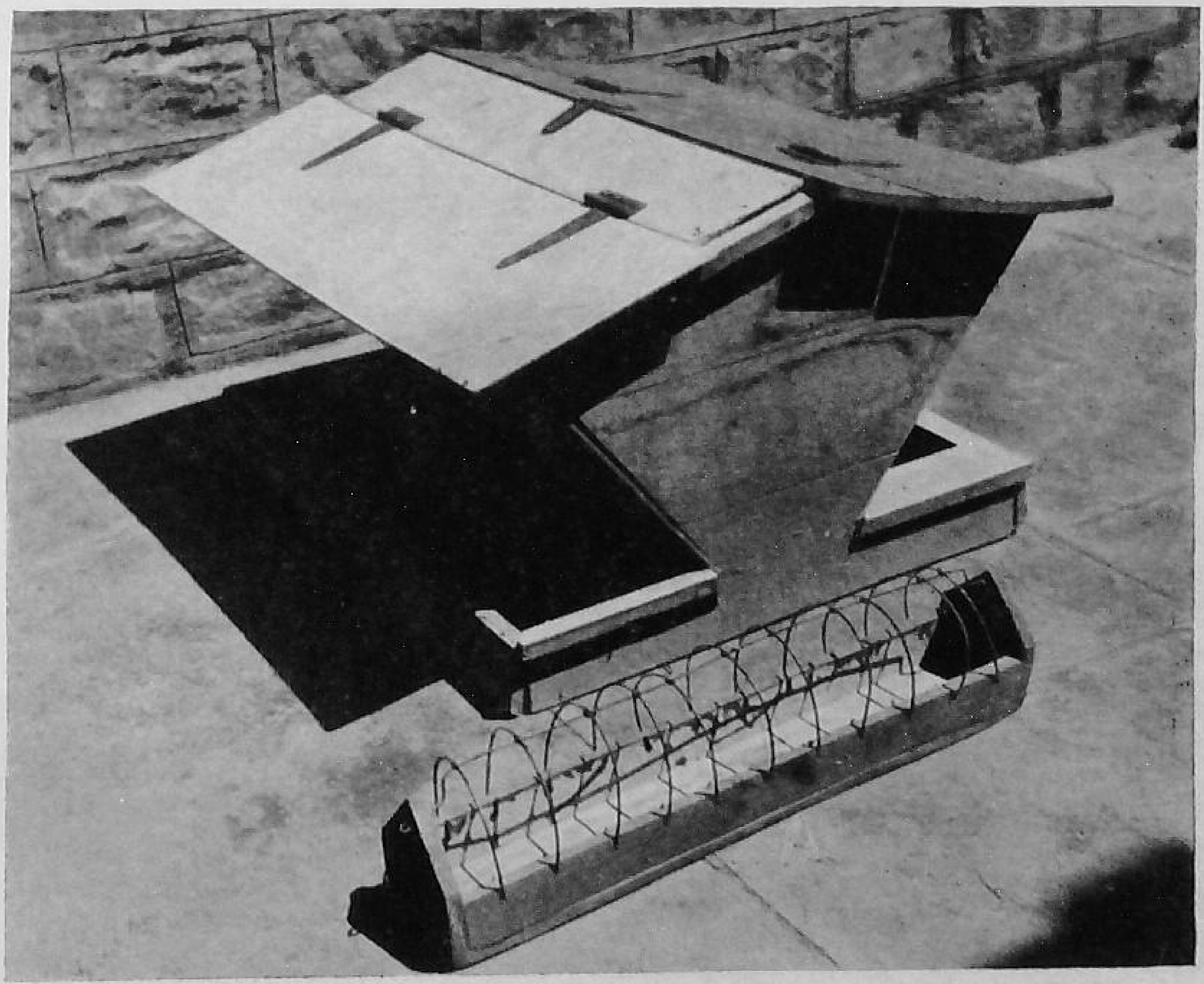
A supply of plenty of fresh and clean water to birds is very essential for proper poultry keeping. A water feeder in which the water level is automatically maintained is available for the purpose. It has a small trough of sheet metal in which a bottle filled with water is inverted. This device costs about Rs. 2.

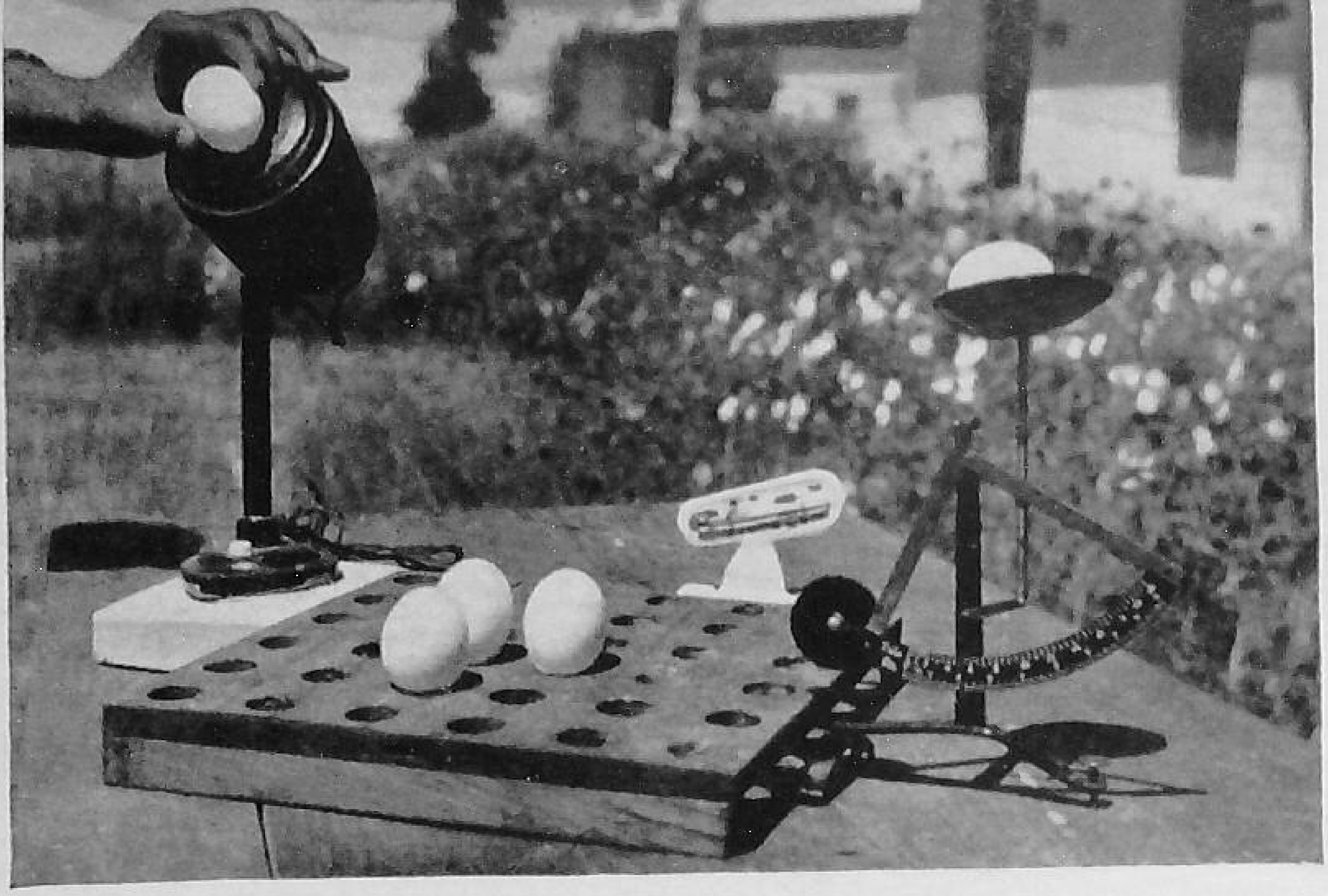
Egg Testing Equipment: For examining eggs whether they are good or bad, an oil lamp candler or an electric candler is available. The electric candler usually has a 40 or 50



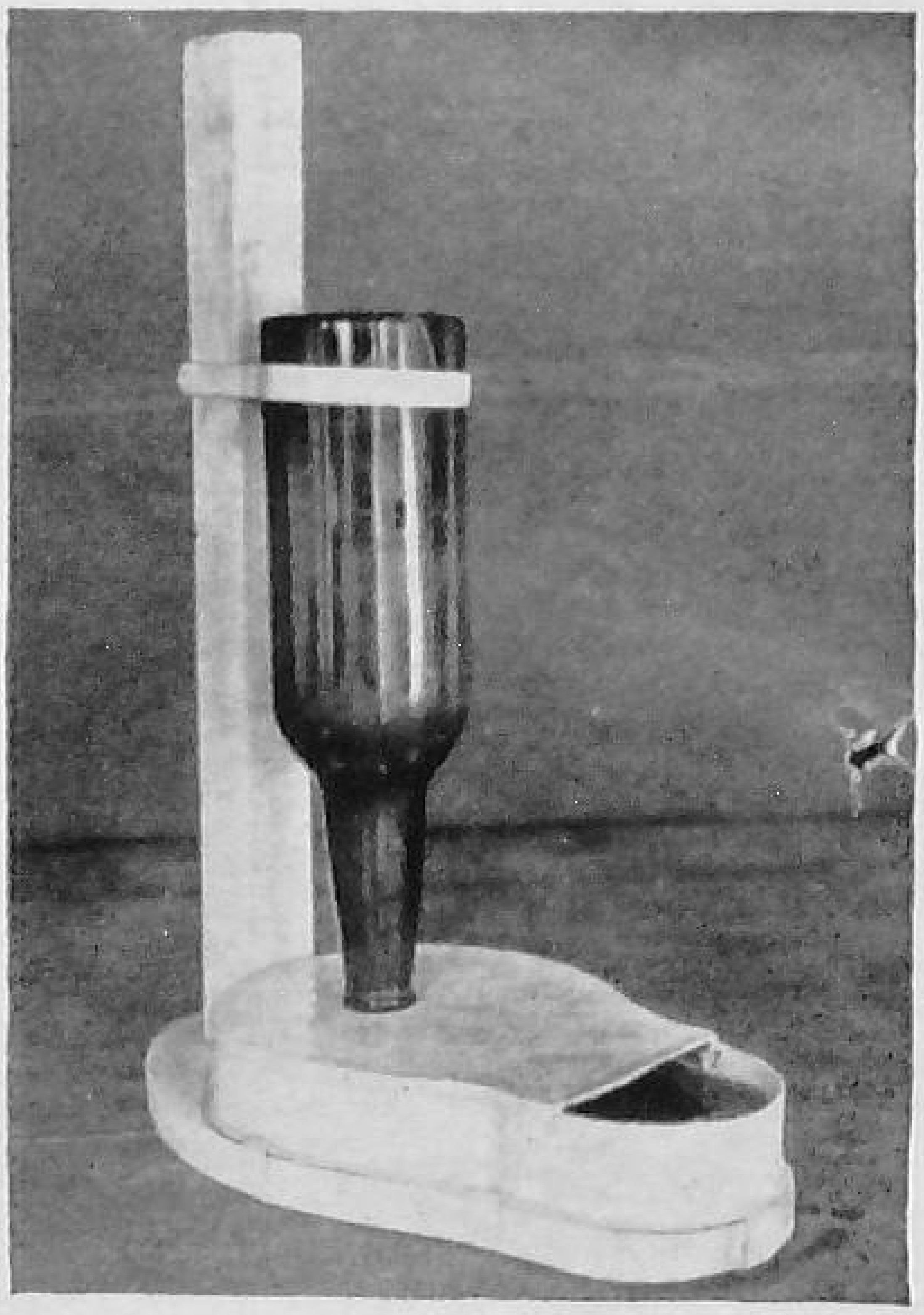
An Adult Green Leaf Feeder (top centre) and a Chicken Feeder

A Grain Hopper (top) and a Mash Feeding Trough

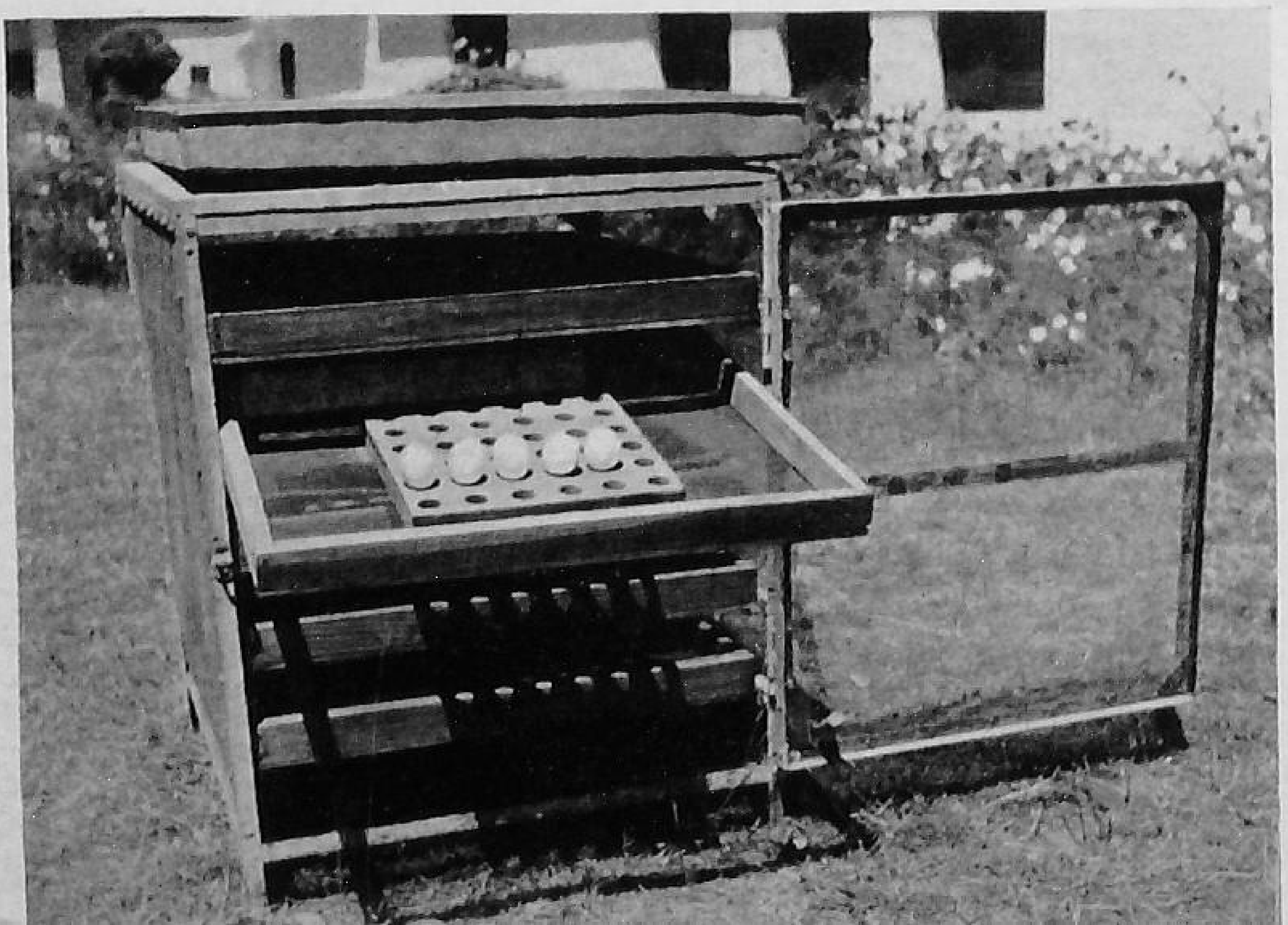




An Electric Candler (left)
and an Egg Balance (right)



A Water Trough



An Egg
Cabinet

watt bulb. When a fresh egg is candled or handled against the lamp, the yolk appears as a very dim shadow which whirls with the white of the egg as it is turned round. In bad eggs the yolk is seen as a dark shadow. An electric candler costs about Rs. 50. An egg balance used for weighing eggs costs Rs. 10.

EGG STORING EQUIPMENT: Eggs are stored, immediately after grading, into a cabinet where the temperature is maintained at about 55°F and the relative humidity at 75 per cent. Eggs are placed on a wire-netting so that they do not touch each other. The moisture is maintained in the cabinet by means of a soaked burlap.

For conditions in India, where we require a less costly egg cooling cabinet, the one used at the Extension Training Centre, Kotah, is very suitable. The cabinet takes six trays which are prepared out of wire-netting. All the sides of the cabinet are also of wire-netting. At the top, a water trough is placed. A piece of cloth or thick burlap is dipped into this trough and is kept hanging on the sides. The water in the trough keeps the burlap wet and the temperature inside the cabinet is considerably reduced. The cabinet can be locked as a protection against cats and other animals. Where *khus* is available, it can also be used. The cabinet costs about Rs. 100.

INCUBATORS: Incubators are used for hatching eggs artificially while the natural way of hatching them is under hens. The artificial method has several advantages over the natural one like:

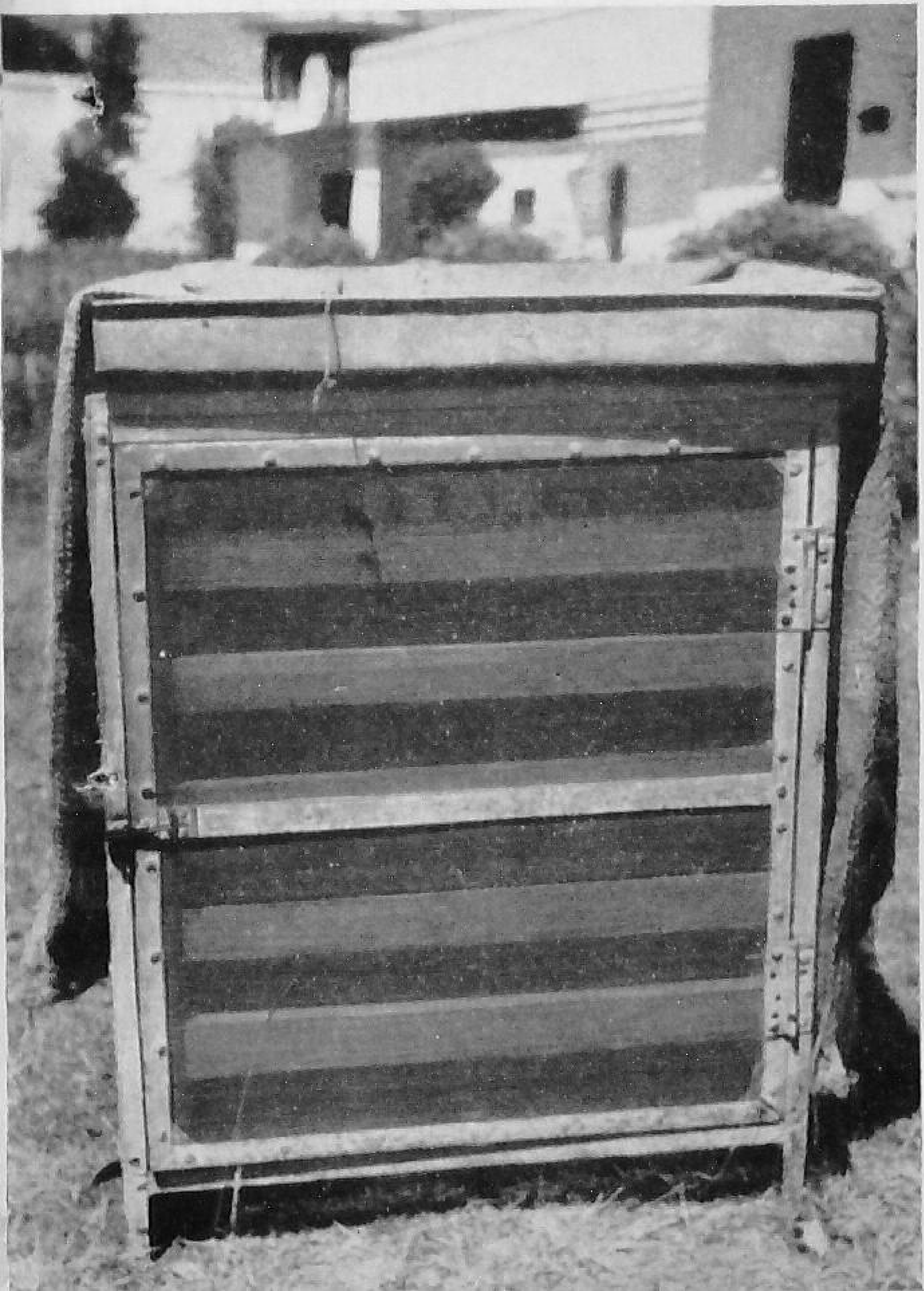
1. Chicks can be hatched whenever desired.
2. A large number of chicks can be hatched at one time.
3. There is relatively less labour involved in artificial incubation.
4. Baby chicks can be sold whenever desired by the owner.

An incubator consists of an egg chamber, a temperature regulator or thermostat, a humidifier and a ventilating device. Eggs are placed in the egg chamber trays. The temperature

regulator maintains even temperature in the egg chamber during the 21 days' incubation period.

The heat for incubation may be obtained by using oil, gas, coke or electricity. The incubators are classified as hot air and hot water types depending on the method used for transferring heat to the egg chamber. In small incubators hot air is used while hot water is used for the purpose in big incubators.

An Egg Incubator with an Oil Stove Burner



An Egg Cabinet Covered with Burlap Dipped in a Water Trough to Keep it Cool

A Beehive

Correct Type of Shed that Should be Provided for a Beehive

Parts of a Beehive

CHAPTER 17

BEE-KEEPING EQUIPMENT

Bee-keeping has been recommended as a profitable side industry for the farmers. Bee-keeping does not require much investment and efforts. Once the bee colonies have been established, there is very little to be done by the farmer.

Described below are some of the most important instruments and tools required for efficient bee-keeping.

BEEHIVE: Beehives are usually made of wood and the cost of a standard beehive comes to about Rs. 25 including the frames which are placed inside it.

The beehive consists of two compartments. In the lower compartment bigger frames are placed whereas smaller frames are placed in the upper compartment. It is from the combs generally, which are constructed in the upper frames, that honey is obtained. In the lower frames the bees store their eggs. The beehive is placed on a pole to which a circular water container is attached at the bottom. This is to prevent white ants and other insect enemies of bees from climbing on to the beehive. The beehive can be transported from place to place. A roofing should be provided above the beehive so that the temperature does not affect the activity of the bees.

The frames have two nails at the top to lift them whenever required. The distance between two frames should be so regulated that the combs do not touch each other. A standard unit consists of eight frames in each compartment. The All-India Bee-keepers' Association has specified uniform sizes of beehives so that they can be mass manufactured.

BEEHIVE ACCESSORIES: A bee-veil, a smoker and a hive tool are important accessories required while handling a beehive. The bee-veil is put on by the operator to protect his face and neck from the stinging bees while handling the colony. It costs about Rs. 5.50.

A smoker is used by the bee-keepers to introduce smoke into the hive to drive the bees away. To produce smoke, dry decayed weeds are used. The smoker has a wind-bag which is held by the operator in his hand. When it is pressed, the smoke is forced into the hive.

In order to introduce a new colony into the hives a number of accessories such as a queen crate and a swarm bag are required.

The queen crate is a small wooden box with a hole covered with wire screen. It is used for transporting the queen. It costs about 50 naye paise. A cloth swarm bag is used for collecting swarms. It costs about Rs. 1.50. A comb cutter costing Re. 1 is used for cutting comb foundations, and an embedder costing Rs. 1.50 is used for fixing comb foundations into the frames. A male bee trap costing Re. 1 is used for catching drones.

Honey Extractors: Extraction of honey from the comb is one of the most important operations. The crude method of extracting honey followed in olden times was squeezing the combs by hand. By this method the cells in the honey comb are destroyed, and the honey also gets spoiled as it gets mixed with wax and eggs. By the modern method, in which centrifugal force is used, the combs do not get disturbed at all.

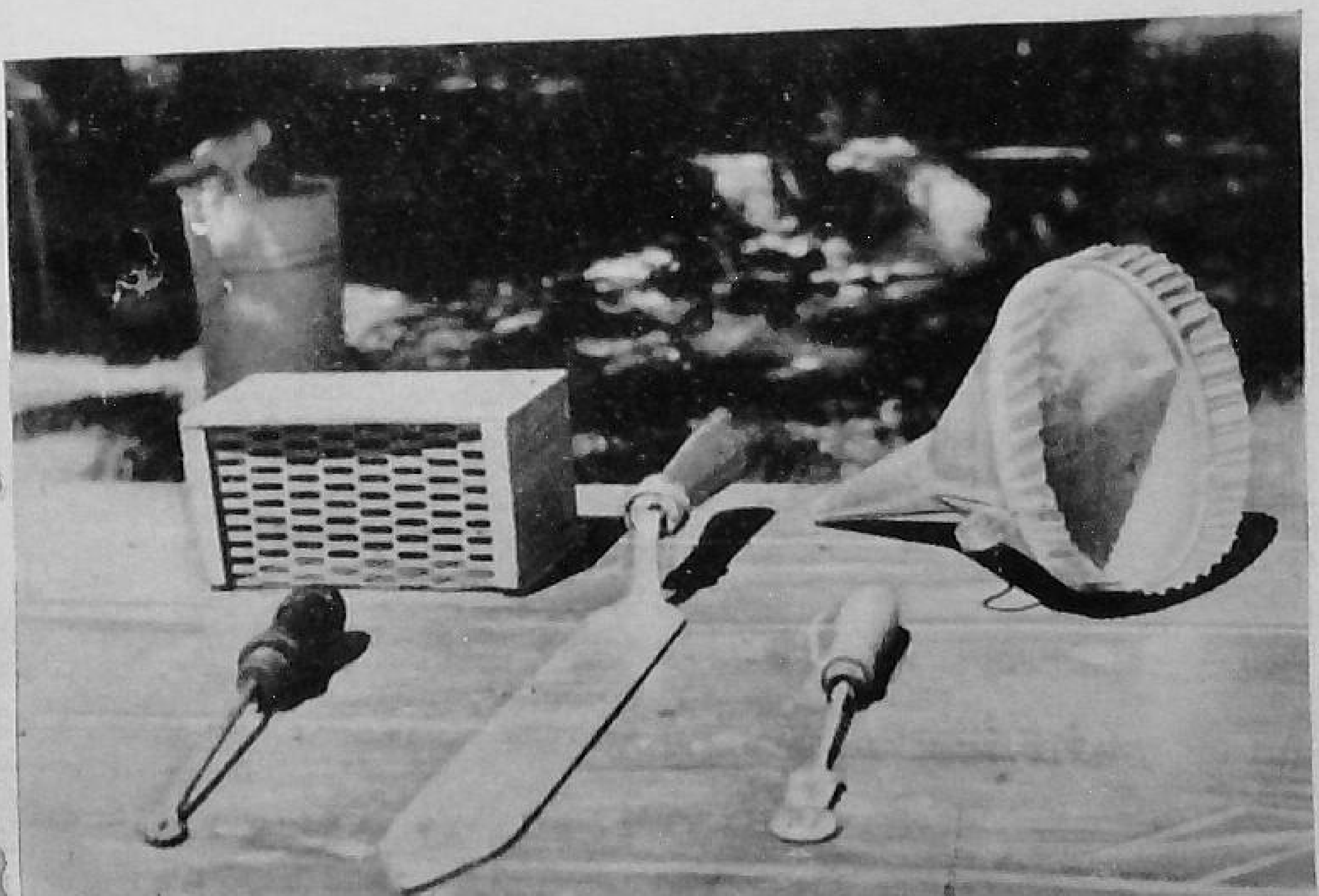
The frames are placed in a honey extractor after decapping the honey cells and are revolved at a great speed. Honey is thrown out from the cells by the centrifugal force without distrubing the comb. About 120 revolutions per minute are required to extract honey.

Different types of honey extractors in which gears are used are available in the market. Their cost ranges from Rs. 40 to 50.

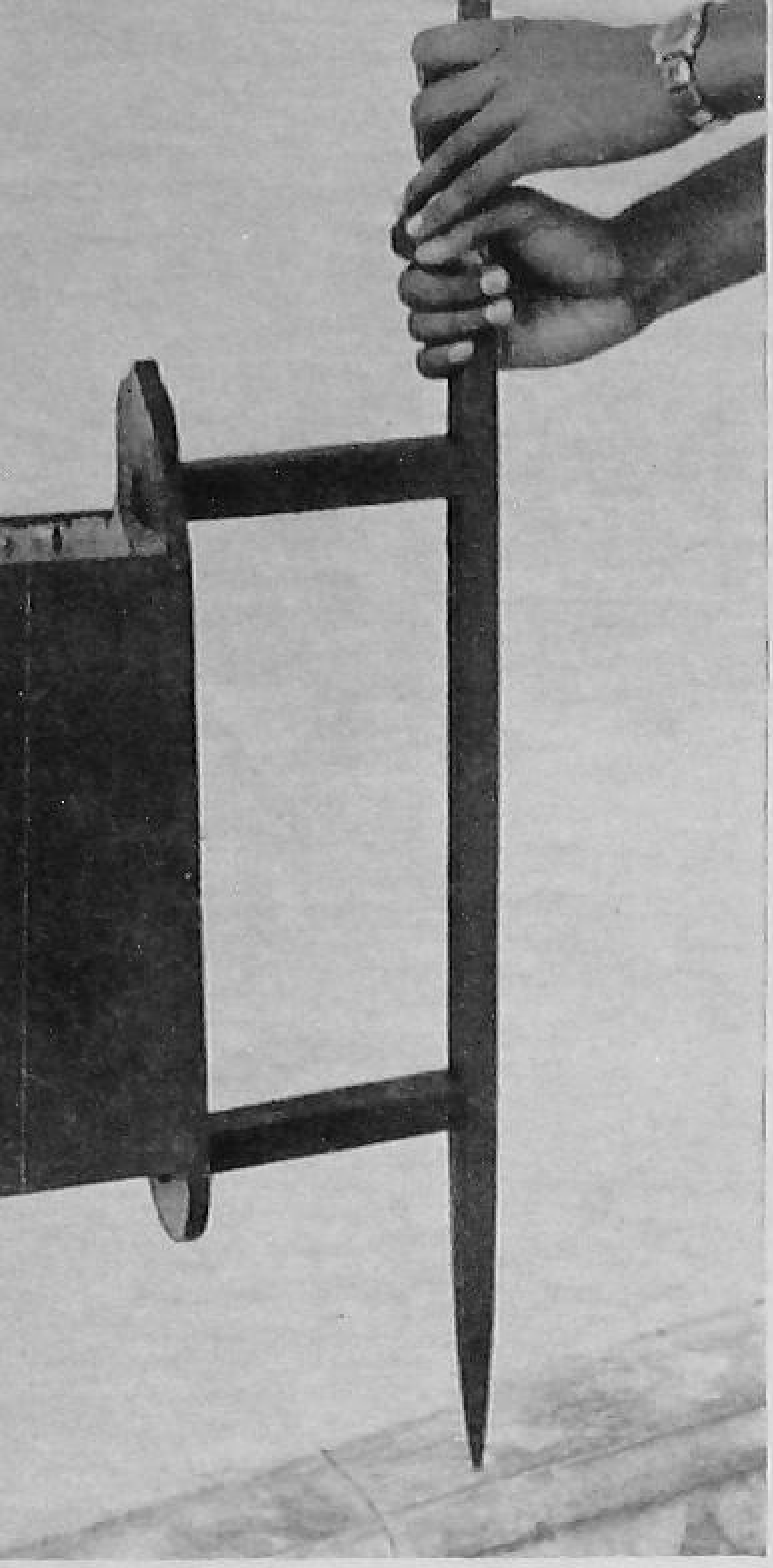
The author has developed a simple honey extractor costing about Rs. 5. Gears are not used in this machine. It consists of a box attached to an axle by a 'U' clamp or by cross ties. The box can hold one or two frames at a time. The machine is placed on the ground on the pointed end of the axle which is used as a pivot, and is rotated by hand.

An Operator with a Veil using a Swarm Bag

Smoke being introduced into a Beehive with the help of a Smoker

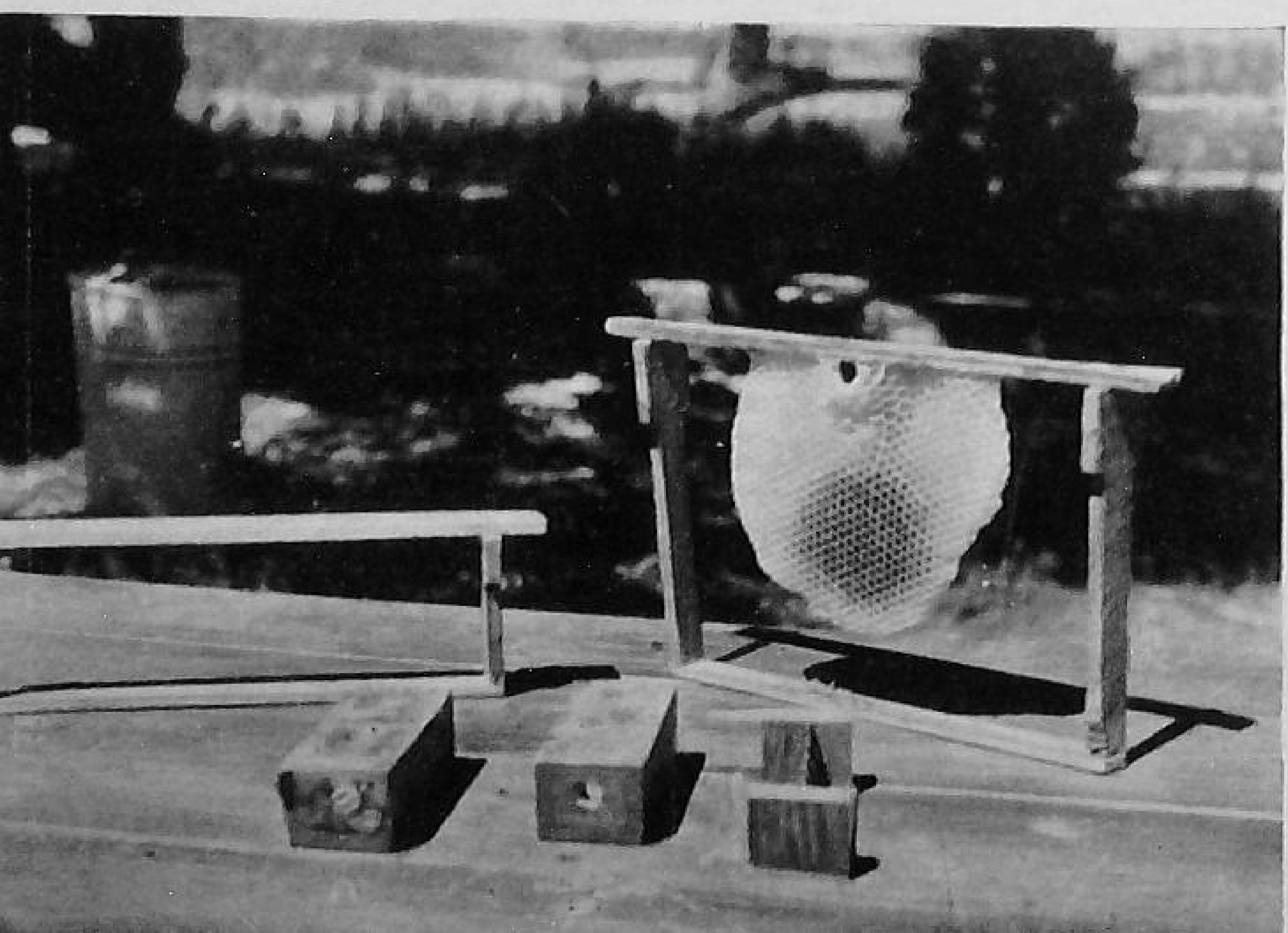


(Left to right) A Male Bee Trap, a Comb Cutter, a Comb Embedder, a Comb Cutter and a Funnel



A Simple Honey Extractor

A Honey Extractor



(Left to right) A Small Frame, Queen Crates and a Big Frame with a Comb

The knife used for decapping honey cells costs about Rs. 3.75.

The total cost of all the equipment necessary for maintaining two or three beehives comes to about Rs. 100. This can be recovered within a year from the sale of the honey produced.

CHAPTER 18

DIESEL ENGINES

Diesel engines are probably the most popular internal combustion engines used for stationary or mobile work in agriculture. They have been in use for many years and are very reliable provided clean fuel is used.

Diesel engines are also known as compression ignition engines because the essential feature of these engines is the compression of the charge of air which produces a temperature higher than the self ignition point of the fuel and the subsequent ignition of the fuel immediately after its injection. The design of a diesel engine is the same as that of a petrol engine except that the injection system replaces the carburetor and a higher compression replaces the ignition system.

Diesel engines are classified as high and low speed diesels according to their revolutions per minute. Engines with a speed of 500 revolutions per minute or more are said to be high speed engines.

Some of the important advantages of the diesel engines are enumerated below.

Simplicity : There are no complicated or moving parts such as the carburetor and the spark plug.

Reliability : Diesel engines have a long life and give dependable service with a little attention and careful maintenance.

Fuel economy : These engines have a higher combustion efficiency, meaning thereby that complete combustion of the fuel is obtained. This leads to more work hours per gallon of fuel.

Less of noise : Diesel engines are comparatively less noisy and give better pressure on the pistons.

Low maintenance cost : A well-desgined diesel engine works at lower operating temperatures and pressures and, therefore, frequent repairs are not required.

Clean exhaust : An important advantage of a well-maintained diesel engine is its clean exhaust which helps in keeping the injectors, pistons and valves free from carbon sticking.

Care and Maintenance : It is more important to use clean fuel in diesels than in petrol engines because the fuel is directly injected into the combustion chamber and if there is some dirt or dust in it, injection is affected resulting in less power. Because of the importance of clean fuel, the engines have cleaning units such as a screen in the filler of the fuel tank, a sediment bowl at the bottom of the fuel tank and primary and secondary fuel filters. The primary fuel filter cleans the fuel before it goes into the fuel pump and the secondary filter cleans it before it goes to the fuel injection pump.

The fuel tank should be kept full at night to prevent condensation. In case the engine runs out of fuel, it should be primed till all the parts are full with fuel. The fuel pump is a very simple mechanism but it is manufactured with considerable precision, and special equipment is required to repair and adjust such a pump.

The important feature of the injection pump is that it is timed to the engine so that the fuel is injected into the combustion chamber at exactly the right time. The pump has a governor and it is usually designed to receive pressure lubrication from the lubrication oil system of the engine. The operator must take special care of all the fuel lines, the fuel injector pump and the injector nozzles. He should be extremely careful in handling these parts. If any major defect occurs, it is important that these parts are serviced by competent servicemen using proper equipment.

The servicing of the rest of the diesel engine is similar to the servicing of a petrol or a paraffin engine. The fuel pump receives its drive from a timing gear and a small cam operates the plunger. The fuel is metered to the plunger barrel by means of a metering needle which is controlled by the governor. The operator should not try to adjust the displacement valve or meddle with the overflow valve as they both

control the amount of fuel that goes to the engine. These are very delicate adjustments. The timing of the pump is, however, very simple and the operator can adjust it provided he follows the procedure given in the manufacturer's instruction manual.

The nozzle controls the high pressure which is required to inject the fuel into a highly compressed combustion chamber. The pressure in this chamber is usually between 1,800 and 2,000 lb. per square inch. The nozzles send a spray into the cell and simultaneously evenly throw the atomised fuel into the main combustion chamber for preignition which is required to start the first stroke.

The nozzle should be washed with clean diesel fuel. In improved types of diesel engines, a small cell is provided. The injector nozzle injects a spray into this cell at about four degrees past dead centre, and momentarily stores fuel there while the outer spray ignites. Then, as the piston goes down on the power stroke, the cell feeds fuel all the way down to give a long power stroke. This also avoids complete combustion at top dead centre which puts a severe strain on the engine.

The cylinder of a diesel engine is different from that of a petrol engine. The design of the head is such that it gives a 15 : 1 compression ratio, and the combustion chambers the main turbulance chamber and the other cell are embodied in it. This is one of the outstanding features of a diesel engine.

It is very important that heavy duty oil is used in the sump and the filter changed regularly.

Most of the usual complaints encountered in the routine operation of a diesel engine are caused by dirt. Consequently the use of clean fuel is of paramount importance.

Following are some of the usual difficulties encountered in running a diesel engine and their possible reasons.

I. Hard starting

- a. Air in fuel lines or filters.
- b. Low fuel pressure because
  1. the overflow valve is stuck open,
  2. the shut-off valve is closed and,
  3. leaky fuel inlet lines.

c. Wrong injection pump timing.
d. Compression under 325 lb. at 150 R.P.M.
e. Cranking speed under 115 R.P.M.
f. Clogged or dirty filters.
g. Octane number of fuel too low.
h. Temperature below 25°F.

II. Poor idling

a. Air in fuel lines or filters.
b. Wrong idle adjustment.
c. Overflow valve sticking.
d. Octane number of fuel too low.
e. Air in fuel lines or filters.
f. Leaky fuel inlet lines.
g. Leaky engine valves.
h. Water in fuel.
i. Nozzle valve operation.

III. Loss of power

a. Low and uneven compression.
b. Wrong injection pump timing.
c. Wrong valve lash.
d. Defective nozzles.
e. Air in fuel lines or filters.
f. Clogged or dirty filters.
g. Dyna-cell carboned up.
h. Defective injection pump.

IV. Poor fuel economy

a. Wrong injection pump timing.
b. Defective nozzles.
c. Wrong valve lash.
d. Low and uneven compression.
e. Water temperature too low.
f. Leaky high pressure fuel lines.
g. Dyna-cell carboned up.

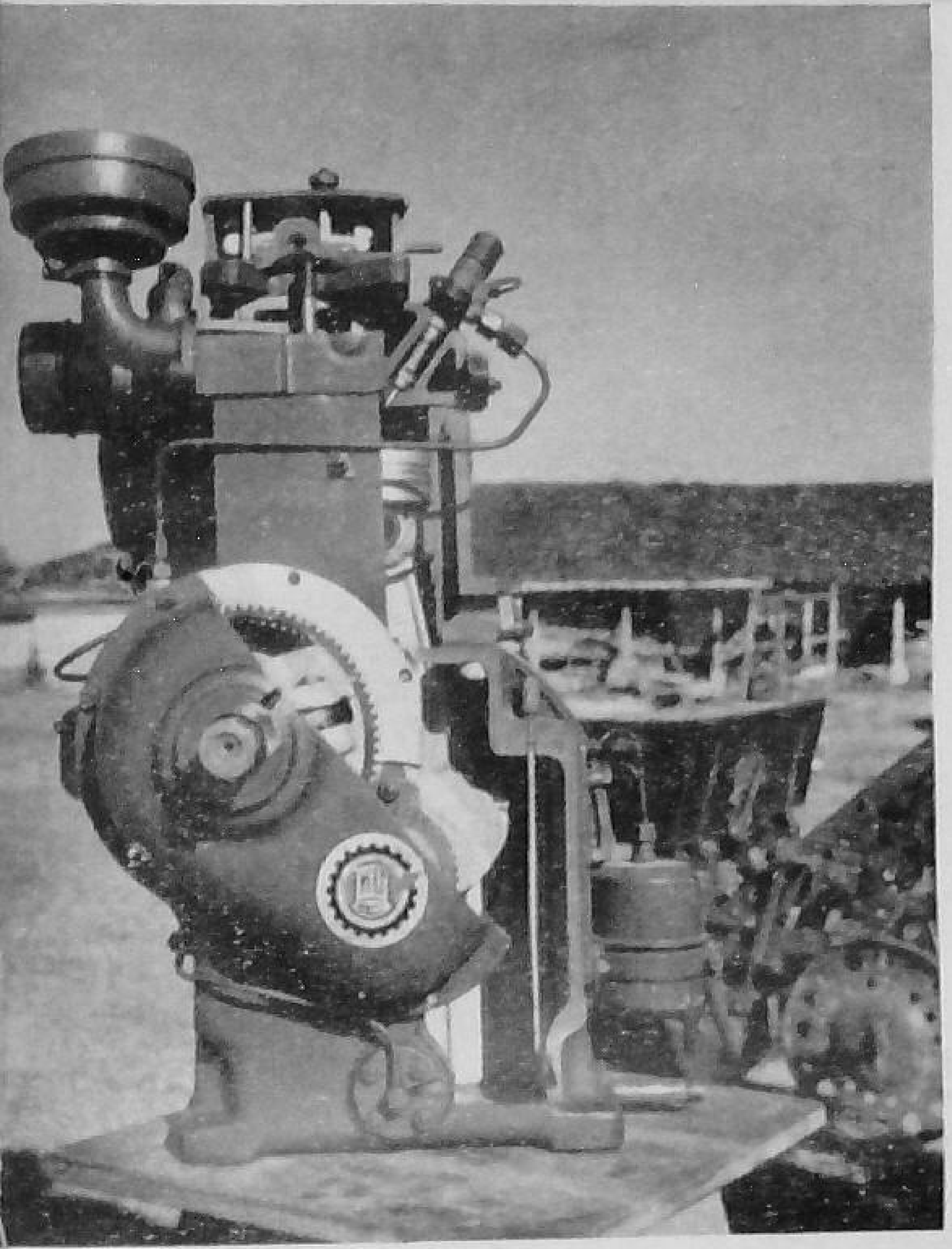
V. Excessive smoking

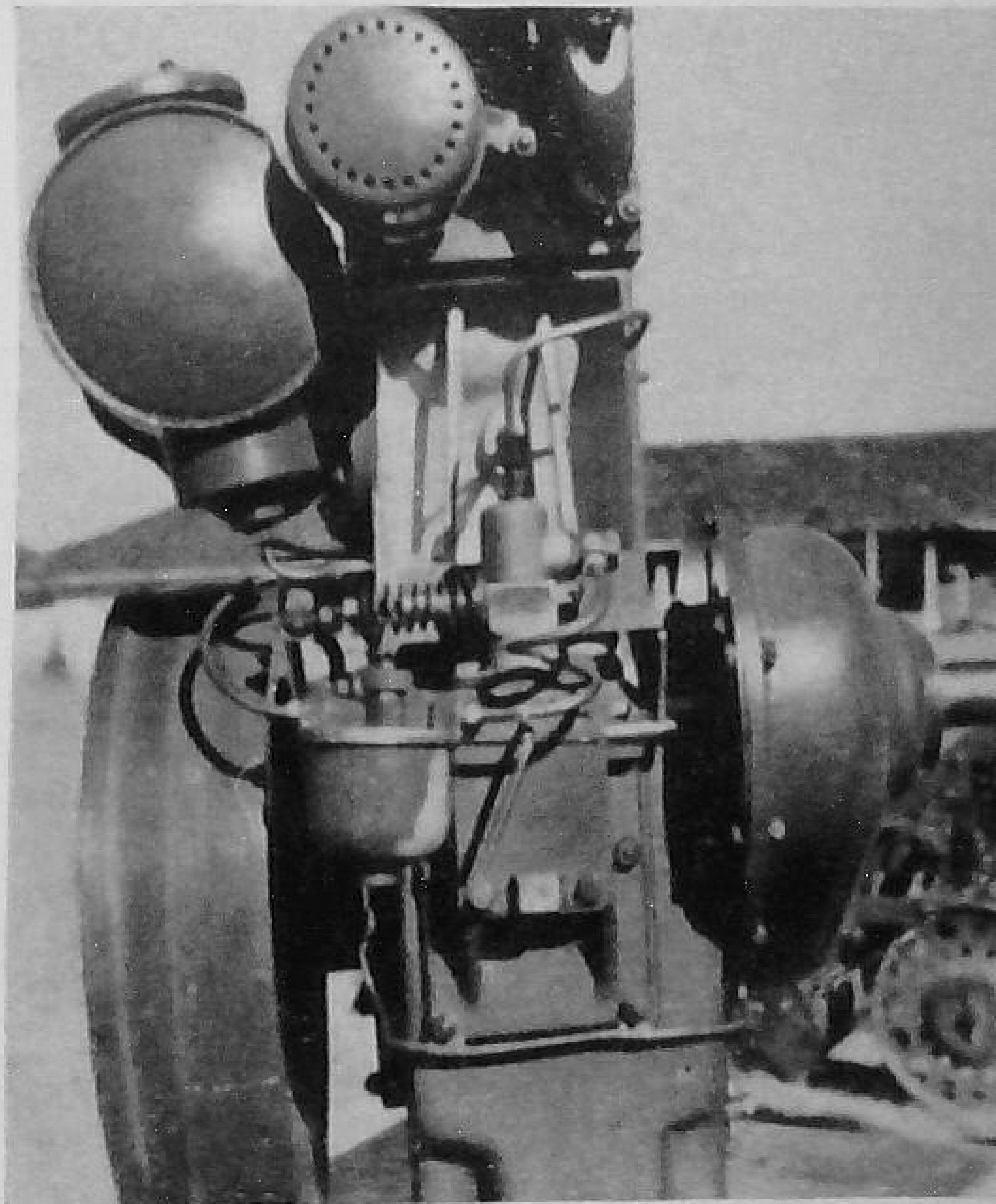
a. Wrong injection pump timing.
b. Dyna-cell carboned up.
c. Defective nozzles.
d. Low or uneven compression.

e. Water temperature too low.

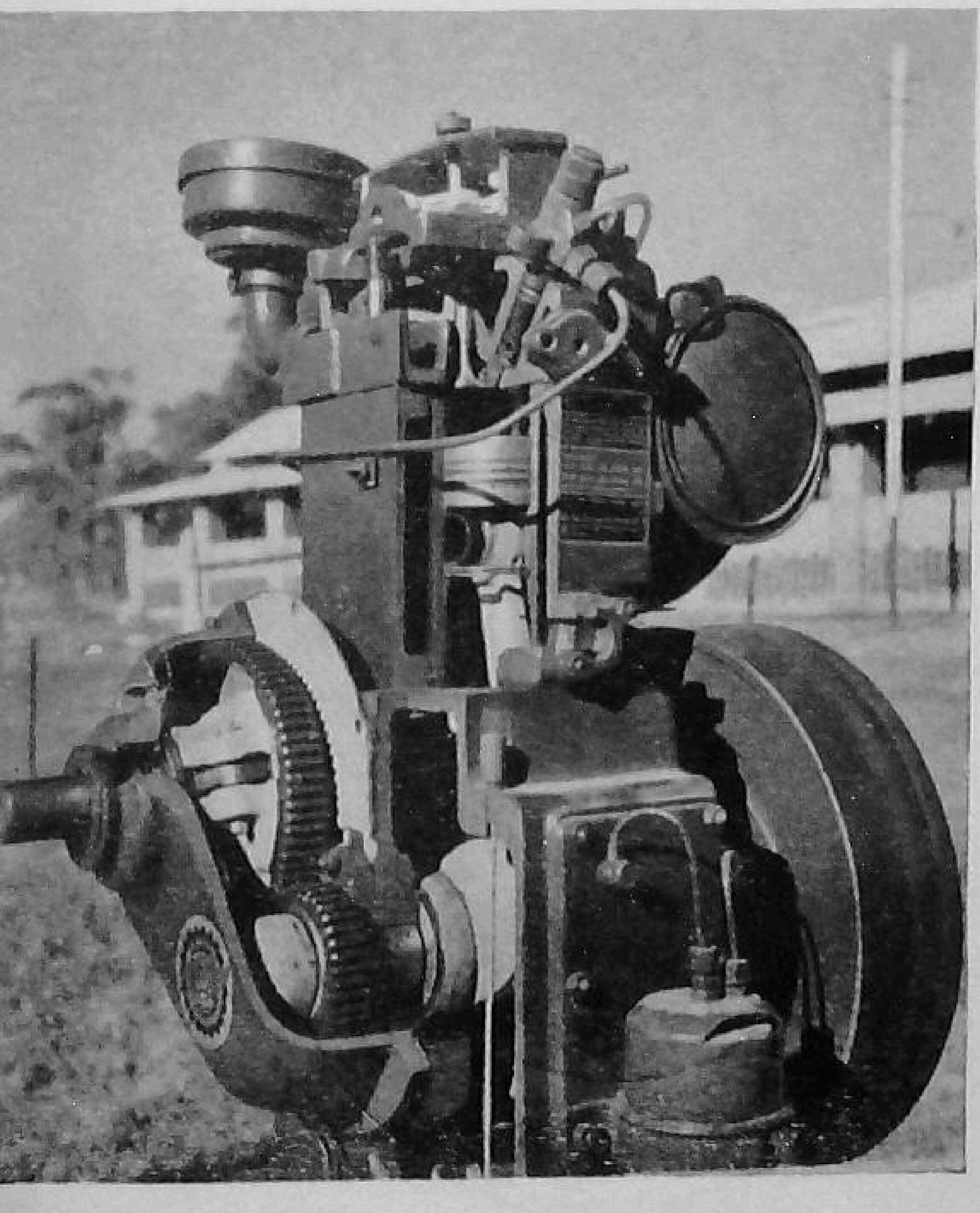
VI. Excessive oil consumption

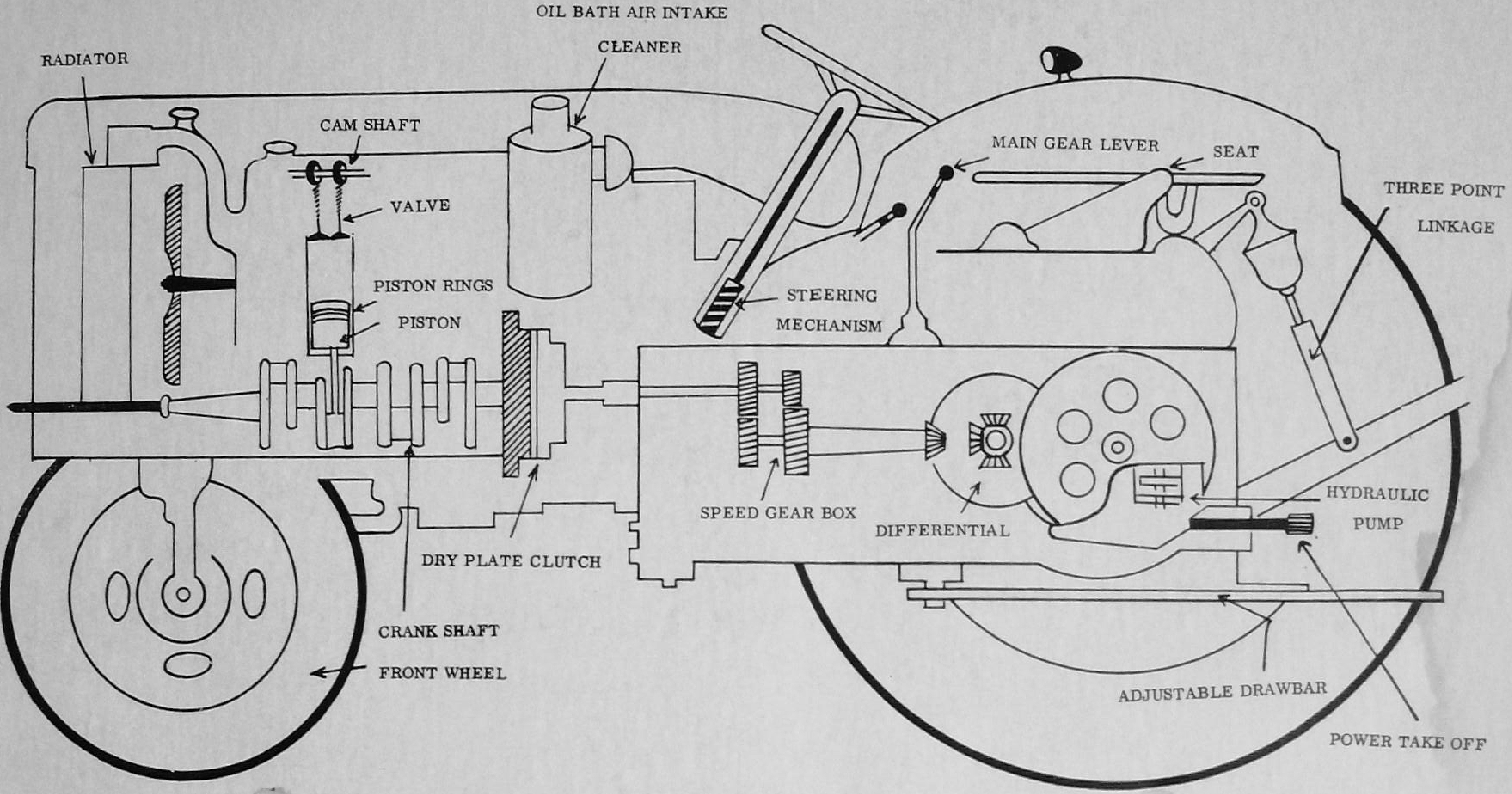
a. Improperly run-in rings.
b. Worn, sticking or clogged rings.
c. Worn piston ring grooves.
d. Worn or scored pistons.
e. Worn or scored cylinders.
f. Worn main and rod bearings.





Three Different Views of a Cut-out Model of an Oil Engine Showing Different Parts





PARTS OF A TRACTOR

Chapter 19

TRACTORS AND TRACTOR-DRAWN IMPLEMENTS

Tractors are getting more and more popular in India. But due to their high price and costly maintenance and operation, they are beyond the reach of an average Indian farmer. Only rich landlords with large estates can afford them.

Tractors by themselves are not agricultural implements. They are a source of power, as is a bullock. Behind a tractor suitable agricultural implements have to be attached for performing agricultural operations such as ploughing, harrowing, seeding, harvesting, etc.

A tractor can be used both for mobile as well as stationary operations. The mobile operations consist of ploughing, harrowing, etc., and the stationary operations consist of pumping, fodder cutting, etc. For normal conditions, 20 to 30 h.p. tractors are useful. Tractors with trailers are useful for transportation also.

The construction of the tractor is almost similar to the construction of a motor car. Tractors are run on petrol, paraffin or diesel oil. Diesel oil is the most popular fuel because it is cheap and diesel engines are simple and sturdy in construction.

A tractor mainly consists of the engine, the clutch and gears, the differential wheel and the power take-off for stationary use. The construction and operation of a tractor diesel engine is similar to other diesel engines. Instead of having a single cylinder diesel engine, tractors may have four to six cylinder diesel engines to provide greater power. All the precautions for running the diesel engine, as described previously, should be followed in the case of a tractor also. Particular attention should be given to the cleanliness of tne fuel.

The engine of a tractor consists of cylinders, pistons,

connecting rods, a crank shaft, a fly wheel, spark plugs and a carburetor (in the case of petrol and paraffin engines only). The cooling systems use either water or air. Oil or grease is used as lubricant. Arrangements for forced automatic lubrication are also incorporated in some tractors.

Implements and Accessories

In order to use tractors in paddy fields, skeleton wheels made of angle iron have been devised. The weight of the tractor is thus distributed and these wheels do not allow the tractor to sink down in the mud. In some makes, adjustable lugs as in the case of "Bower's wheels" are used. These lugs remain at a slightly higher position than the rubber tyres allowing the tyres to be used on plain roads. When the tractor enters the field, the lugs help the tractor to move in muddy soils. The brake linings of the tractor wheels are usually waterproof so that when the wheels are submerged in water the brake linings are not affected.

Following agricultural implements are used with the tractors.

1. Mould-board ploughs
2. Disc ploughs
3. Tined cultivators
4. Disc harrows
5. Seed-drills
6. Harvesting machines or combine harvesters
7. Fodder cutters
8. Centrifugal pumps

The last two are operated by a stationary tractor.

The implements listed above are similar in construction to the bullock-drawn implements except that they are bigger in size.

Recently, efforts have been made to modify tractor-driven agricultural implements to suit Indian conditions and crops. Two such prominent and successful experiments are mentioned below.

(1) A disc cultivator which can be used in wetland paddy cultivation has been devised. The cultivator has two

levelling boards attached behind it in the Indian fashion. It is claimed that the use of this implement gives a satisfactory puddle and makes the soil ready for transplantation. The cost of this attachment is about Rs. 1,200. Along with this implement, skeleton wheels have to be used so that the tractor does not sink down in the puddled paddy field.

(2) In Madhya Pradesh and Bombay, tractor *bakhars* which are a replica of the bullock-drawn *bakhars* used by the local farmers, are being manufactured. The cost of such a tractor *bakhar* comes to about Rs. 400. It has a 5′ wide blade, and a tractor can harrow 20 acres per day with the *bakhar*.

CHAPTER 20

SURVEYING

Surveying means the determination of the relative position of points on or near the surface of the earth. Such determination involves measurement of distances, computation of areas and measurement of differences in elevation.

Agricultural surveying includes establishment of farm boundries, computation of field areas, adjustment of lines and elevations of irrigation or drainage channels, and laying out contour bunds for controlling soil erosion. In surveying accuracy is of utmost importance.

For any approximate calculation, distances can be measured by 'pacing.' If the length of one's pace is measured and the average arrived at, one can get a fair idea of the distance between two points by pacing. For accurate measurment chains are used. The Engineer's chain consists of 100 links of 1′ length each. The Gunter's chain is composed of 100 links of 7.92″ each. It is 66′ in length. This chain was developed especially for measuring units of acres and miles. One Gunter's chain length is equal to four rods, 80 chain lengths are equal to one mile and 10 square chains are equal to one acre. Along with the chain, chaining pins and range poles are used. These poles are about 8′ in length and are painted alternately with bands of red and white. The chaining pins are 12″ long and 1/8″ in diameter. There are 11 chaining pins.

Two men are necessary for chaining. They are known as the head chainman and the rear chainman. To take a measurement, the rear chainman first sticks one of the chaining pins in the ground. The head chainman takes the remaining 10 chaining pins and walks from the original pin along the line towards the ranging pole at the far end of the line. The chaining pins are fixed when they are in line with the ranging pole and the first pin. The distance is then noted down.

It is possible to do most of the mapping and measurement of areas for agricultural purposes with the chain only. The area to be measured is divided into appropriate triangles, measured and plotted on paper. After the area is mapped, the height of the traingle can be measured by a scale, and by using the formula, $\frac{1}{2}$ base $\times$ height, the area of the triangle can be easily determined.

By plane table survey the area of land can also be easily measured. The plane table consists of a drawing board fixed rigidly on a tripod. The second piece of equipment necessary for plane table work is a straight edged rule on which is established a line of sight, parallel to the straight edge. This is known as Alidad.

Accurate surveying can be done by chaining the land by "the back and forward ray system."

Levels can be measured by means of a dumpy level which is telescope-like in construction, and a level rod. The dumpy level is adjusted and readings taken over the level rod and measurements are noted along with the distances measured by chain by having one common 'datum' point.

Surveying and levelling essentially being practical jobs, Village Level Worker trainees should take full advantage of all the surveying and levelling instruments maintained at the training institutions.

Chapter 21

VILLAGE ROADS AND TRANSPORT

Roads are said to be the arteries of a nation. They make it easy for villagers to take the agricultural produce from the village to the market and to bring required articles into the village. Roads are particularly useful in rainy season when for want of roads villages get isolated, causing considerable discomfort and losses to the villagers.

A Village Level Worker is concerned mainly with the roads inside the village and the approach roads.

The level of the roads to be constructed should be at least 2′ higher than the surrounding land. Roads should be straight wherever possible, and special care should be taken while constructing small bridges. The Village Level Worker should first prepare an estimate of the cost and materials required for the particular road, taking into consideration the length, width and height of the road and the excavation or filling that would be required.

There are four main types of roads.

1. Concrete roads: Though rather costly, concrete roads are specially suitable for heavy traffic. Their cost ranges from Rs. 60,000 to 80,000 per mile. To construct them, concrete is laid in blocks over layers of bricks and stone ballast. The thickness of the concrete layer is usually between 4″ and 5″. Cement concrete roads are considered the strongest.

Where, because of the cost involved, it is not possible to construct complete cement concrete roads, only cement concrete cart tracks can be constructed. For these tracks, cement concrete is laid only on that part of the road on which the wheels of bullock carts move. A considerable saving can be made this way.

2. Metalled roads: Metalled roads normally cost about Rs. 40,000 per mile. They consist of earth or *murum* packing with a 3″ deep layer of bricks or round boulders over which

stone ballast is spread and pressed by rollers. If coal-tar is to be used to make the road water-proof or dust-proof, a layer of fine stone ballast should be spread over the tar and it should be immediately pressed.

3. KANKAR ROADS: Kankar roads cost approximately Rs. 20,000 per mile. These roads cannot be used in rainy season and should be constructed only as a temporary measure.

4. EARTH ROADS: Earth roads cost approximately Rs. 5,000 per mile. These also cannot be used in rainy season and should be constructed only as a temporary measure.

On both sides of the road, leaving a distance of about 3′ to 5′, channels should be provided for carrying away drainage water.

It has been estimated by the Indian Roads Congress that steel tyres of country bullock cart wheels cause damage to roads to the extent of 100 crores of rupees per year. The steel tyres cut into the strongest roads and spoil their surface. After conducting considerable experiments, the Indian Roads Congress have come to the conclusion that the width of the steel tyres should be increased from 2″ to 4″. By having 4″ wide tyres, the damage could be considerably reduced.

Bullock Carts

The bullock cart is probably the most important implement next to the *desi* plough which the Indian farmer possesses. It is used for transporting practically anything and everything. Even in the age of motor cars and trucks, bullock carts hold their own position in rural transport. Eighty per cent of our rural transport, even today, is dependent on bullock carts. In case of short distance haulage, bullock carts even beat motor trucks on economic grounds.

Various sizes of bullock carts are used in India, the main difference between them being in the diameter of the wheels. The diameter of the wheels of carts used in Orissa, Andhra Pradesh and Madras is the biggest in India and it ranges between 5½′ and 6½′. In other areas the diameter ranges between 3½′ and 4½′.

There has hardly been any change in the design of the bullock cart since the days of Mohen-jo-daro. The models of bullock carts found there almost resemble the bullock carts being used in India today. In the last decade, however, sporadic efforts have been made to improve bullock carts, particularly their wheels. Bullock cart wheels with tyres made from coir rope, leather, rubber, etc., have been tried. A costly but useful improvement has been the use of pneumatic tyres.

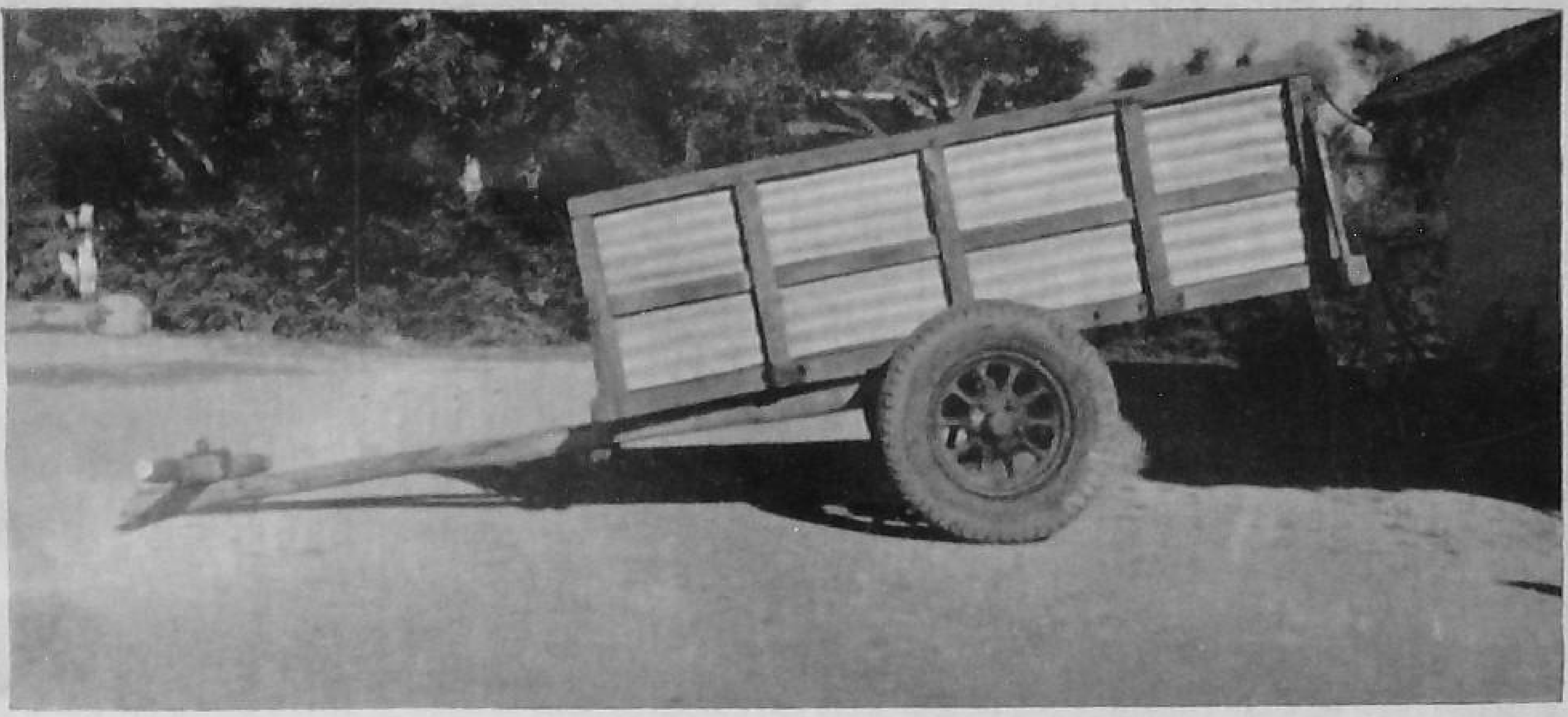
Another improvement, useful to the agriculturist, has been in the design of the bullock cart wherein it is not necessary to unyoke the bullocks at the time of emptying the cart. The cradle of the cart can be tilted independently of the beam. The cost of preparing this attachment comes to about Rs. 20 to 25. The construction consists of a strong steel hinge fixed on the body. Hooks are provided in the front of the cradle to hold it in a horizontal position. At the time of emptying the cart these hooks are released, allowing the cradle to tilt backward.

The provision of ball-bearings in the bullock cart has not proved very useful because of the slow speed at which the cart moves. The carts can be suitably modified to carry grass or fodder by having attachments over the cradle to carry bulky materials.

Yokes

Yokes are an important accessory for the use of bullock power. Without the use of proper yokes, a considerable amount of bullock power is lost. The anatomy of the bullock is different from the anatomy of the horse and the reins and belts used for horses cannot be used for bullocks. Horses apply power more from their chest whereas bullocks can apply power only from a point below the hump at the top of their neck. A bullock's hump is only a store of fat and does not assist in the application of power, but the triangular bone situated beneath the hump from which the spinal column starts, is used for applying power.

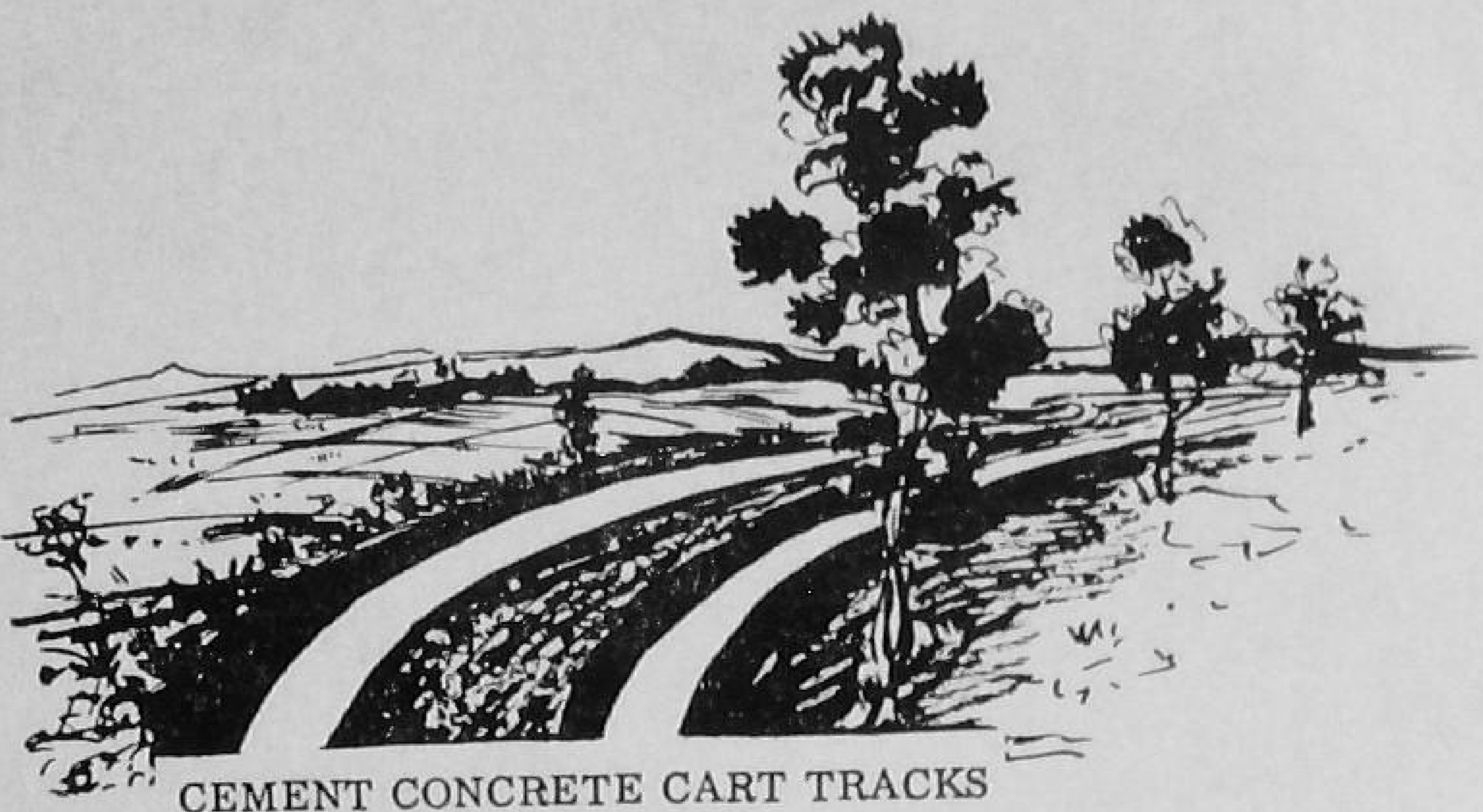
The yoke should properly fit over this triangular bone so that very little friction is created and its maximum possible



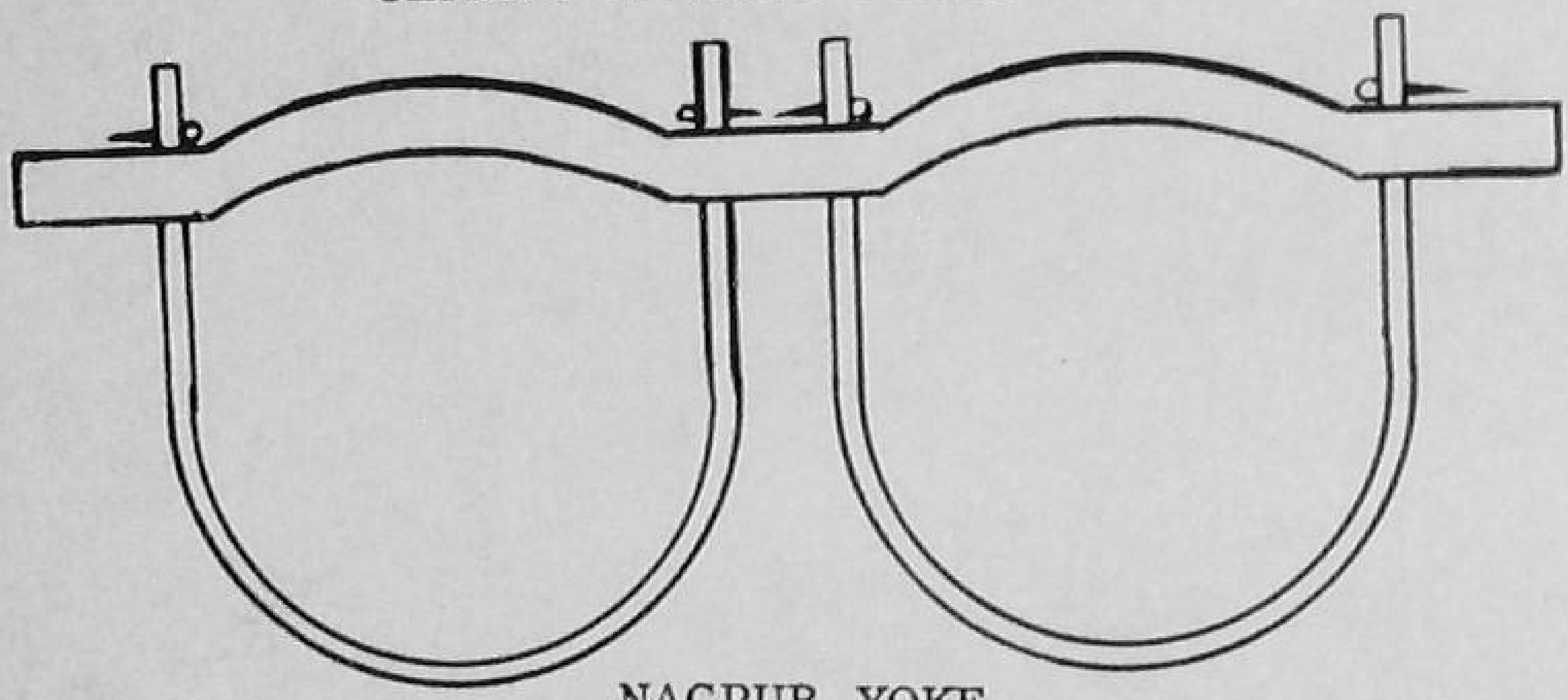
A Bullock Cart with Pneumatic Tyres

A Borer Head of an Earth Borer

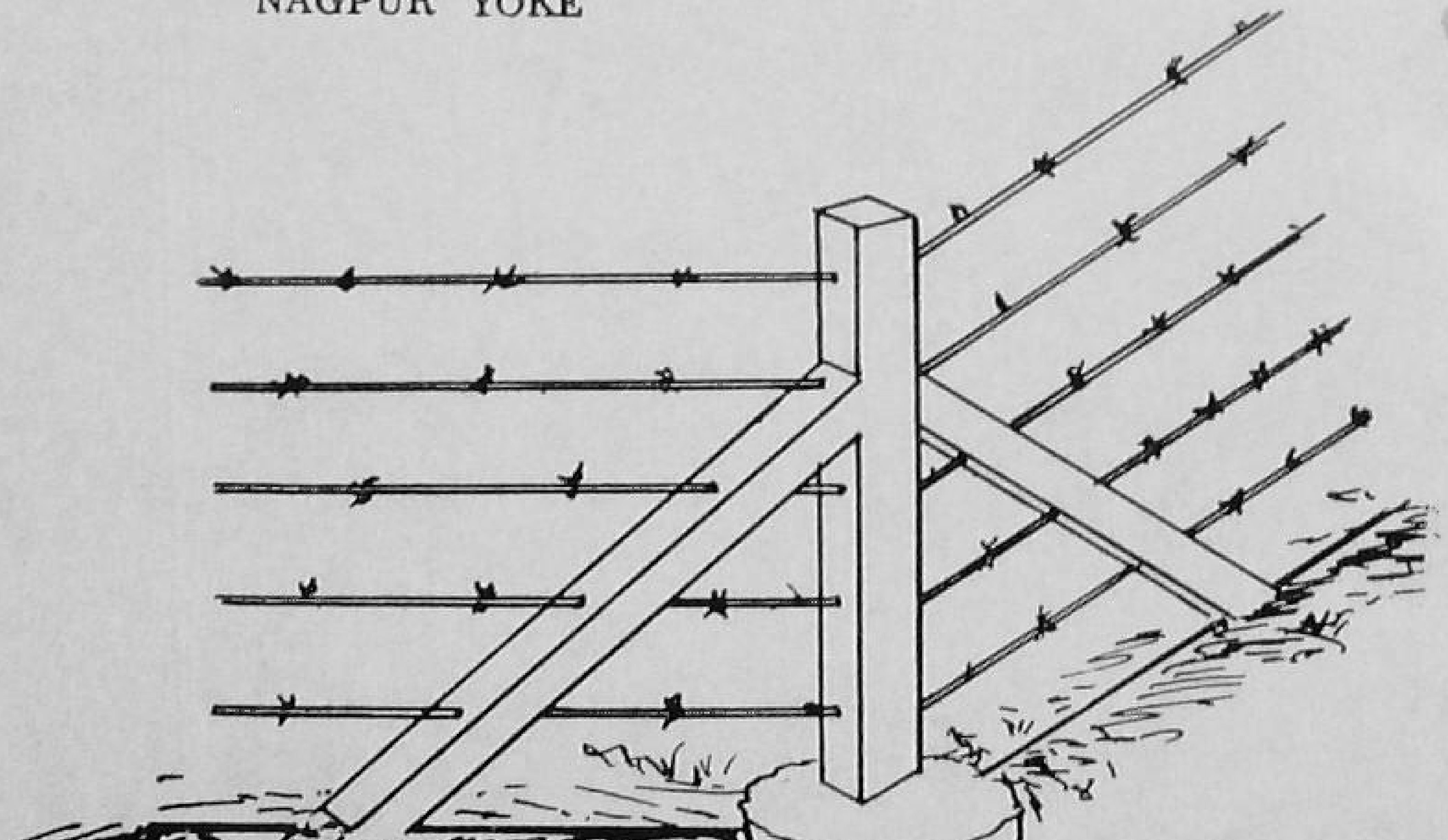
A Bullock Cart with Tilting Mechanism



CEMENT CONCRETE CART TRACKS



NAGPUR YOKE



CORNER POST OF FENCE

area touches the neck bone. By the use of such a well-designed yoke, formation of neck galls, which occur due to faulty yokes, can be avoided. In Orissa, Bengal and Andhra Pradesh only circular poles are used as yokes. These cause neck galls in bullocks and reduce their efficiency.

A survey of various types of yokes used all over India was made some time back by the Allahabad Agricultural Institute and after taking dynamometer trials it was found that the Nagpur yoke was the most efficient one as it allowed bullocks to exert maximum power with comfort. The special feature of the Nagpur yoke is that it is so shaped that it fits very well over the bullock's neck. In tying bullocks, either pipes or ropes can be used over this yoke. Where bullocks are small, the size and weight of the yoke should also be proportionately reduced. Nagpur yokes are being used almost all over the Deccan plateau for centuries.

Chapter 22

FARM BUILDINGS, SANITARY STRUCTURES AND HOUSEHOLD APPLIANCES

Indian farmers live in villages and not in farms like Western farmers. What is meant by farm buildings in India is the residential quarters of the farmer in his village along with a cattle shed and other structures.

Wherever a farm building is to be constructed, attention should be paid to the level of the ground, nearness of the road, water supply and sanitary arrangements. The cattle shed should be as far away from the residential quarters as possible. The use of cement concrete cannot be recommended at present because of the high cost and scarcity of cement. For constructing pucca houses, there is no other suitable economical material like oven-burnt bricks. In certain areas, however, locally obtained stone is cheaper than bricks. Where sun-burnt bricks are used, it is recommended that the bottom three layers of the walls should be constructed of oven-burnt bricks with cement mortar. This does not allow absorption of water by the walls. The rooms should be well ventilated and should have accessories such as cupboards or shelves.

Fences

Normally we do not find fences being used by Indian farmers. If at all there is any fencing it is either for the vegetable crops or orchards. In villages, temporary fences are put up usually by using thorny branches of trees like *babool*. These fences have to be replaced year after year because they get damaged by storms or rains.

A really effective fence is a barbed wire fence fixed on angle irons. These angle irons, in turn, should be fixed in lime mortar or cement concrete foundations. It has been said that the strength of a fence lies in the corner posts because

if the corner posts get loosened, the whole fence line gets out of order. The corner posts, therefore, have to be reinforced by braces. The distance between two wires in a fence depends upon the protection that is required. Normally a distance of 7″ to 8″ is sufficient. In sugarcane fields where there is trouble from pigs, it is advisable to fix one or two wires inside the soil because pigs burrow in the soil and get into the field. The bottom two or three lines should also be about 5″ apart.

Wooden poles, when used for fencing, should be painted with coal tar so that they are not readily attacked by white ants. Only seasoned and dried poles should be used for this purpose and green wood should be avoided. The distance between two poles should be 5′ and the diameter of the pole should be at least 3½″.

Where the soil is alluvial and very soft, it is possible to dig holes for the fence poles by means of an instrument called earth borer. It consists of a borer head attached to a long pipe with a horizontal handle.

The head is made from 1/8″ high carbon steel sheet and its cutting edges have sharp ends. The pipe is 1″ in diameter. It requires two persons to work this borer. A small pit is first dug by a *phawra* and the earth borer is placed vertically in it. It is then turned clockwise with the help of the handle. The earth borer head works like a drill bit. After some turns the head gets filled in with soil. It is then lifted and emptied. This process is repeated. Borer heads are available in sizes of 10″, 12″ and 16″ diameter. The price of an earth borer with 25′ of pipe ranges from Rs. 90 to 110. With such a long pipe the borers can be used for digging holes for bore-hole latrines. For fencing purposes a pipe of about 4′ length is more than enough.

In Western countries, electric fences are also being used but these have not proved useful in India. They have a very limited scope of being used only in big dairies where grazing is controlled and where only cows are kept. The standard electric fencing has not been found effective for buffaloes because they do not feel the electric shock as cows do.

Cattle Sheds

Cattle sheds are of two kinds—one meant for dairy or milch cattle and another for draught cattle.

Cattle sheds should be constructed on a slightly higher ground to afford good drainage. The materials that are locally available like sun-burnt bricks, oven-burnt bricks, corrugated galvanised sheets and asbestos sheets should be used in their construction. The roof can be made of tiles, sheets or some kind of thatching. It is essential to provide sufficient space for the animals to move about in the shed when fixed in the stanchion or when tied by chains. The dung or urine should fall in the channel provided for this purpose. Nearby, drinking water troughs should be provided. The shed should be well ventilated and airy. It should be rain-proof and should offer sufficient protection to animals against heat, storms, etc.

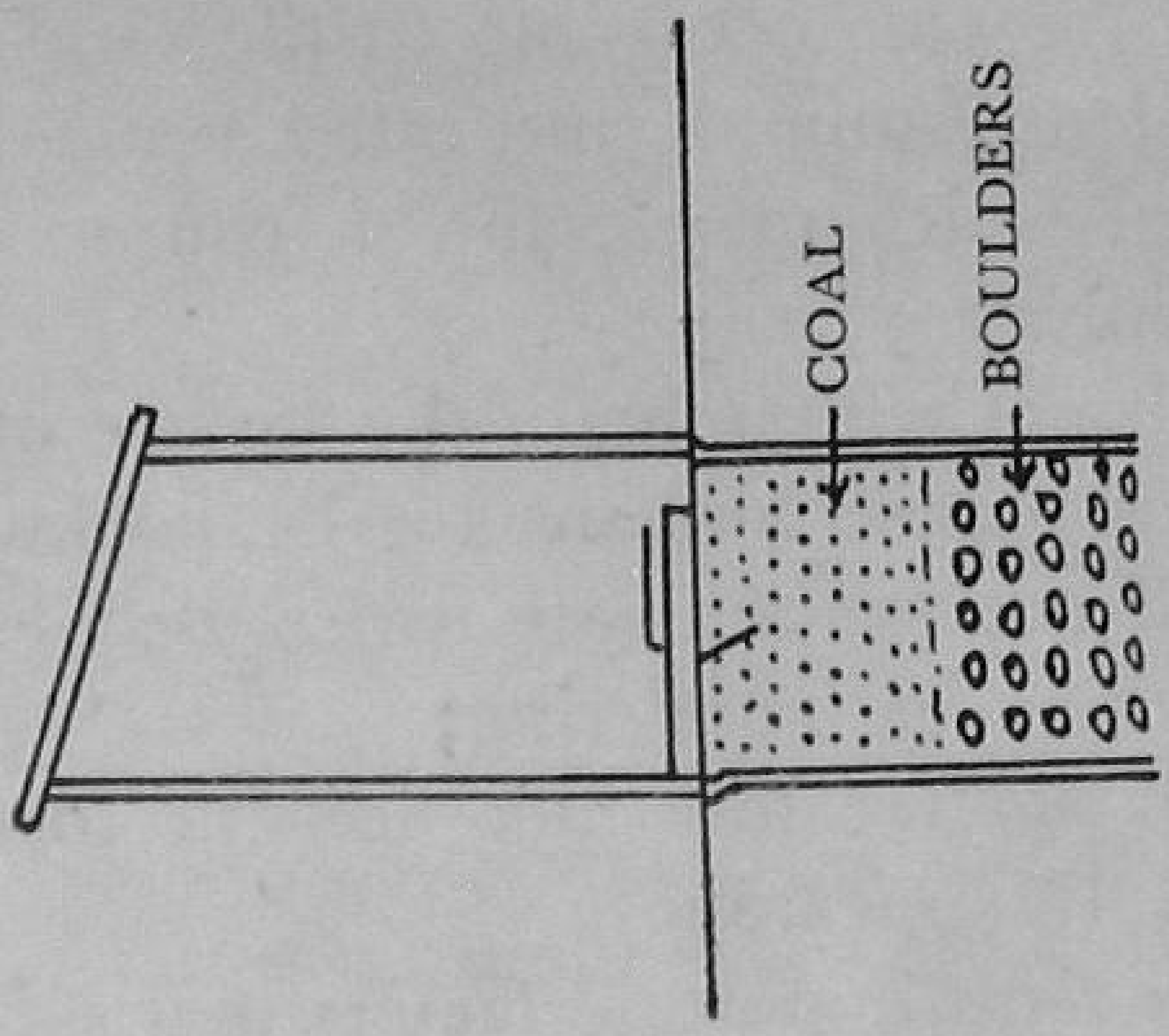
The average cost of building such a pucca cattle shed comes to about Rs. 8 to 10 per square foot. Cheaper cattle sheds can be constructed by using sun-burnt bricks with two top and two bottom layers of oven-burnt bricks. The floor can be prepared by ramming a layer of boulders and *murum.*

Village Latrines

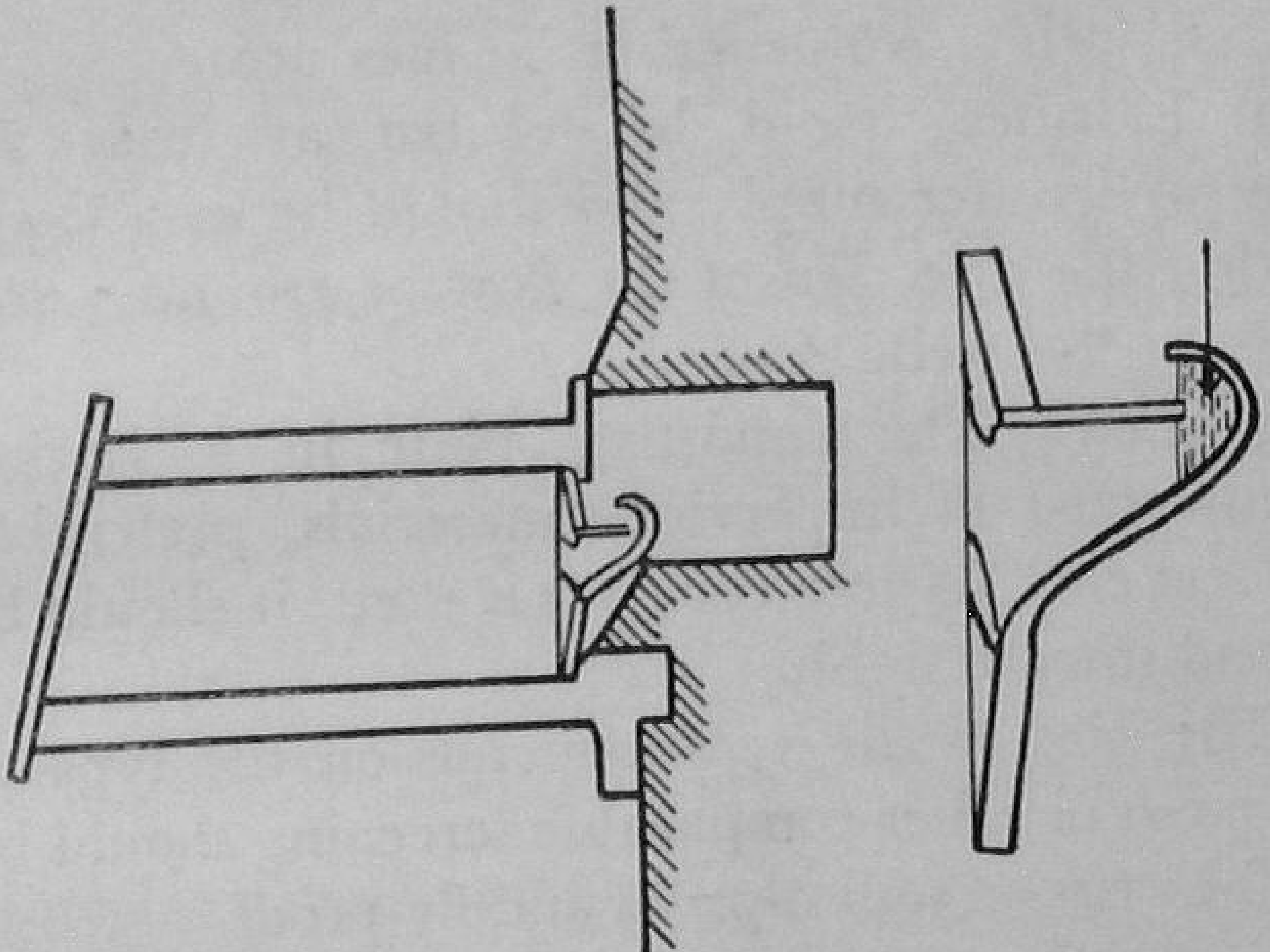
The provision of good and efficient latrines in villages is of utmost importance for maintaining the village population in good health. Nearly 28 lakh people died every year in India from 1940 to 1949, due to filth-born diseases like cholera, dysentery, diarrhoea and typhoid. This figure does not include deaths due to malaria. It has been estimated by the medical authorities that at least 55 lakh persons in India suffer from the above diseases annually. These figures show the enormous importance of really effective and clean latrines for villages.

There are several sanitary methods of human excreta disposal. These methods meet the basic principles of excreta disposal so that the excreta

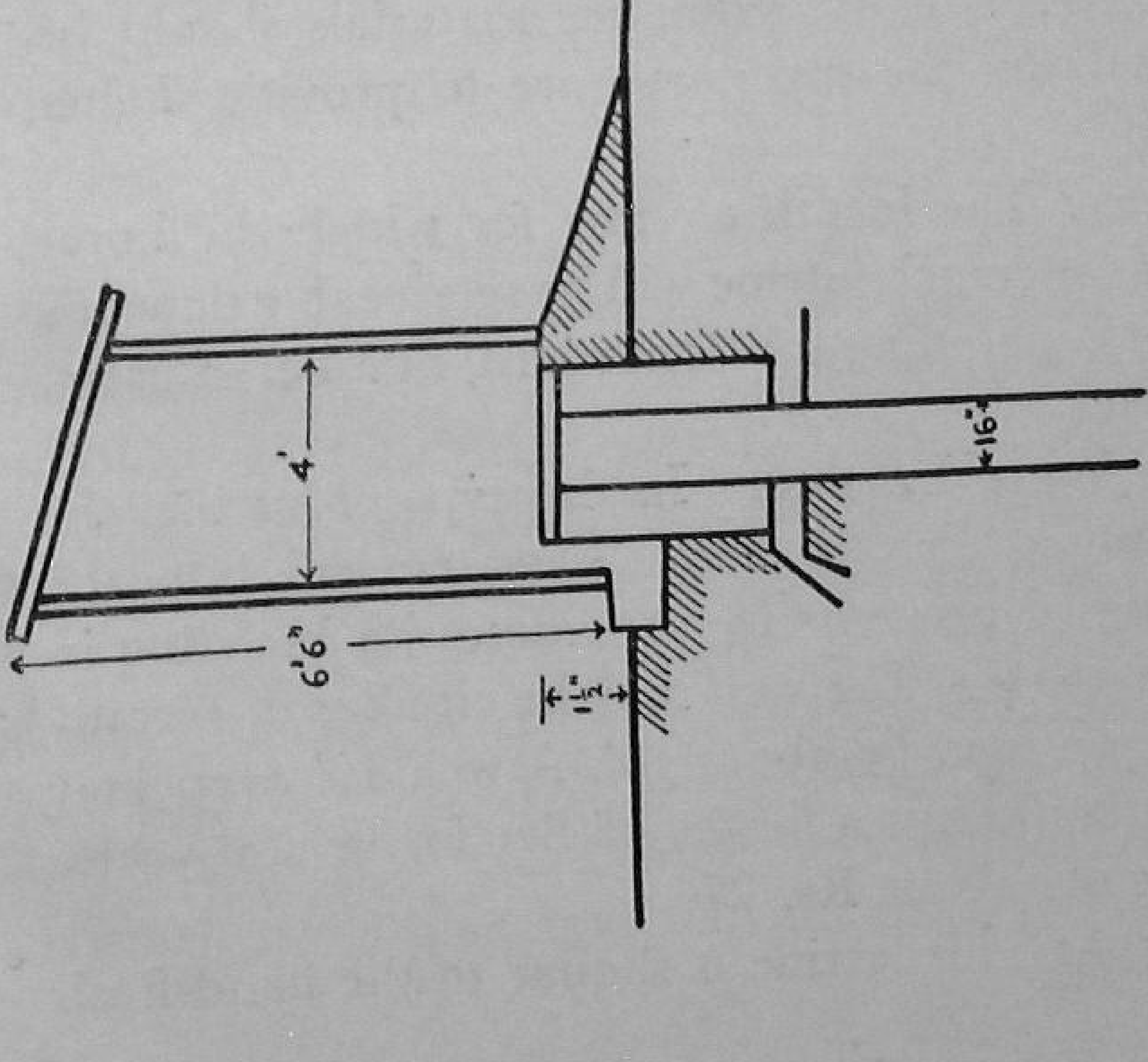
(i) will not contaminate any drinking water or food supply;

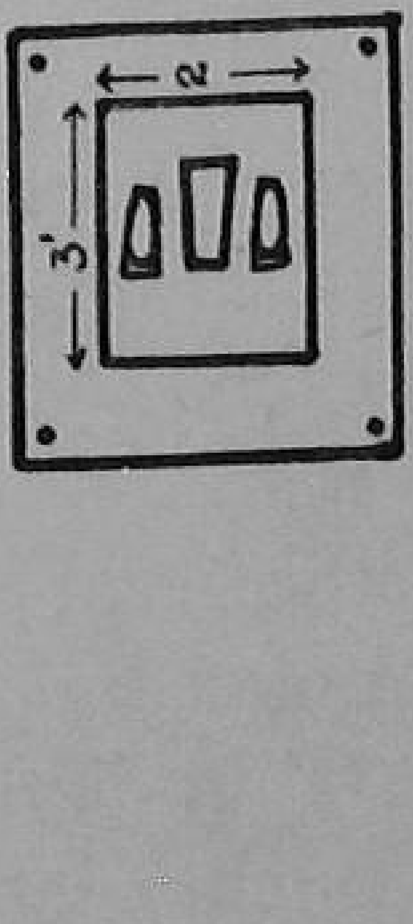


URINAL



WATER SEAL LATRINE





BORE HOLE LATRINE

(ii) will not be accessible to flies and other insects, rodents, animals and other vehicles of transmission which may come in contact with food or drinking water;

(iii) will not contaminate the surface of the soil and thus expose humans to the hookworm disease;

(iv) will not contaminate water used for swimming, bathing or laundering;

(v) will not create a nuisance due to odour or unsightly appearance.

Some of the most important factors that should be taken into consideration while constructing latrines are:

1. *Location*: Latrines should be located at least 50′ away from the well water supply and should be at a lower elevation, so that the direction of the flow of ground water will be away from the well.

2. *Squatting Plate:* The squatting plate in a latrine should be constructed of impervious materials, preferably porcelain or burnt clay. Where concrete is used, it should be given a hard and smooth finish.

3. *Vents:* The size of the vent depends on the type of latrine. Wire mesh or other comparable screening should be used to make the vent mosquito-proof and fly-proof.

4. *Superstructure:* Locally available materials should be used for constructing the superstructure to provide shelter and privacy.

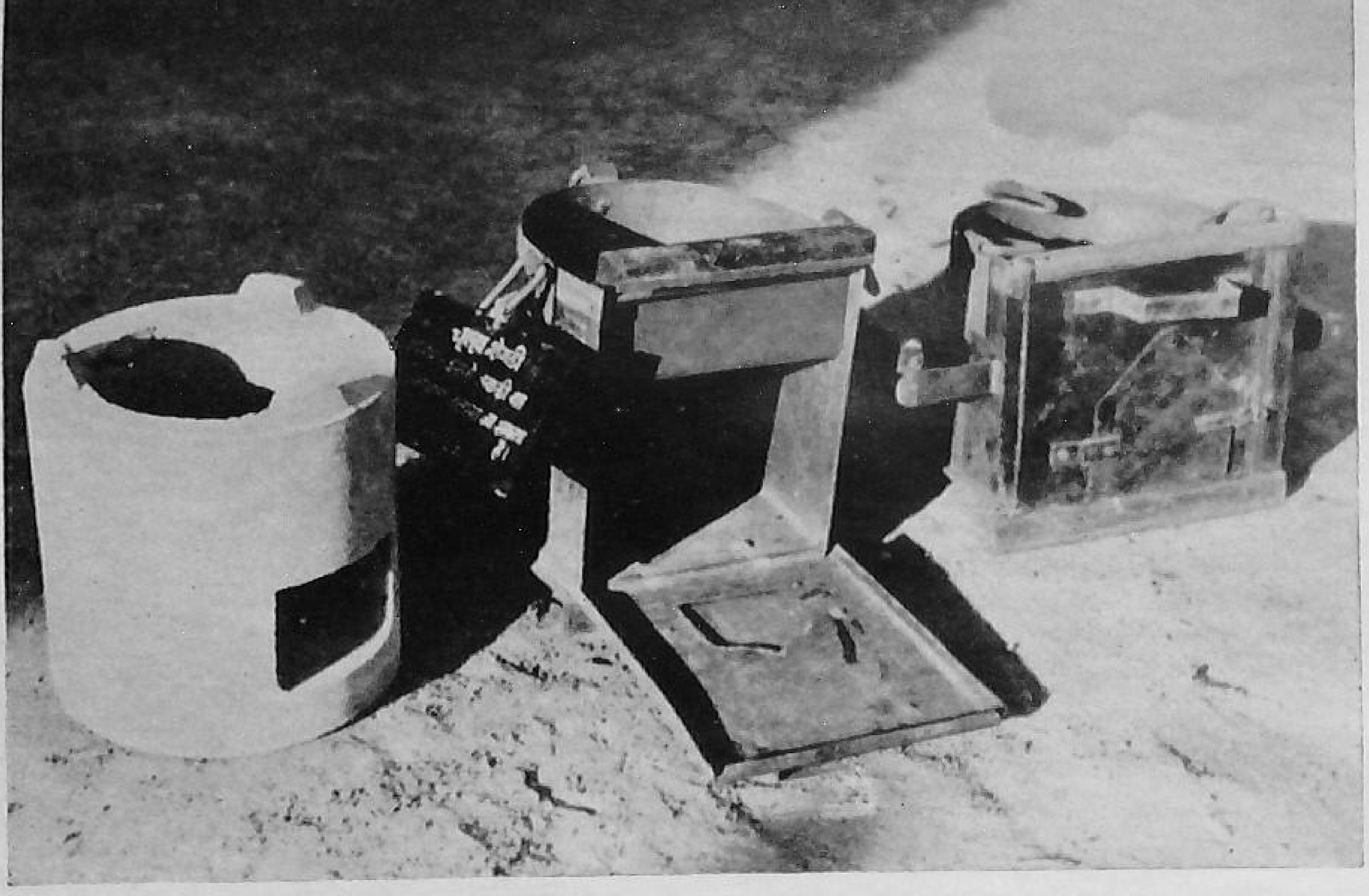
5. *Maintenance:* The length of time for which the bore-hole, the well or the trench latrine will be serviceable depends on several factors, including soil conditions, number of users, care in usage, etc.

HAND-FLUSH WELL LATRINE: In this type of latrine, the excreta is discharged directly from the water seal into the well. The water seal prevents fly and mosquito breeding in the well or the earth pit. The well may be circular or rectangular and its depth may be about 10′. A well 10′ deep and 3½′ in diameter should last a family of five for several years. Such a latrine costs about Rs. 270.

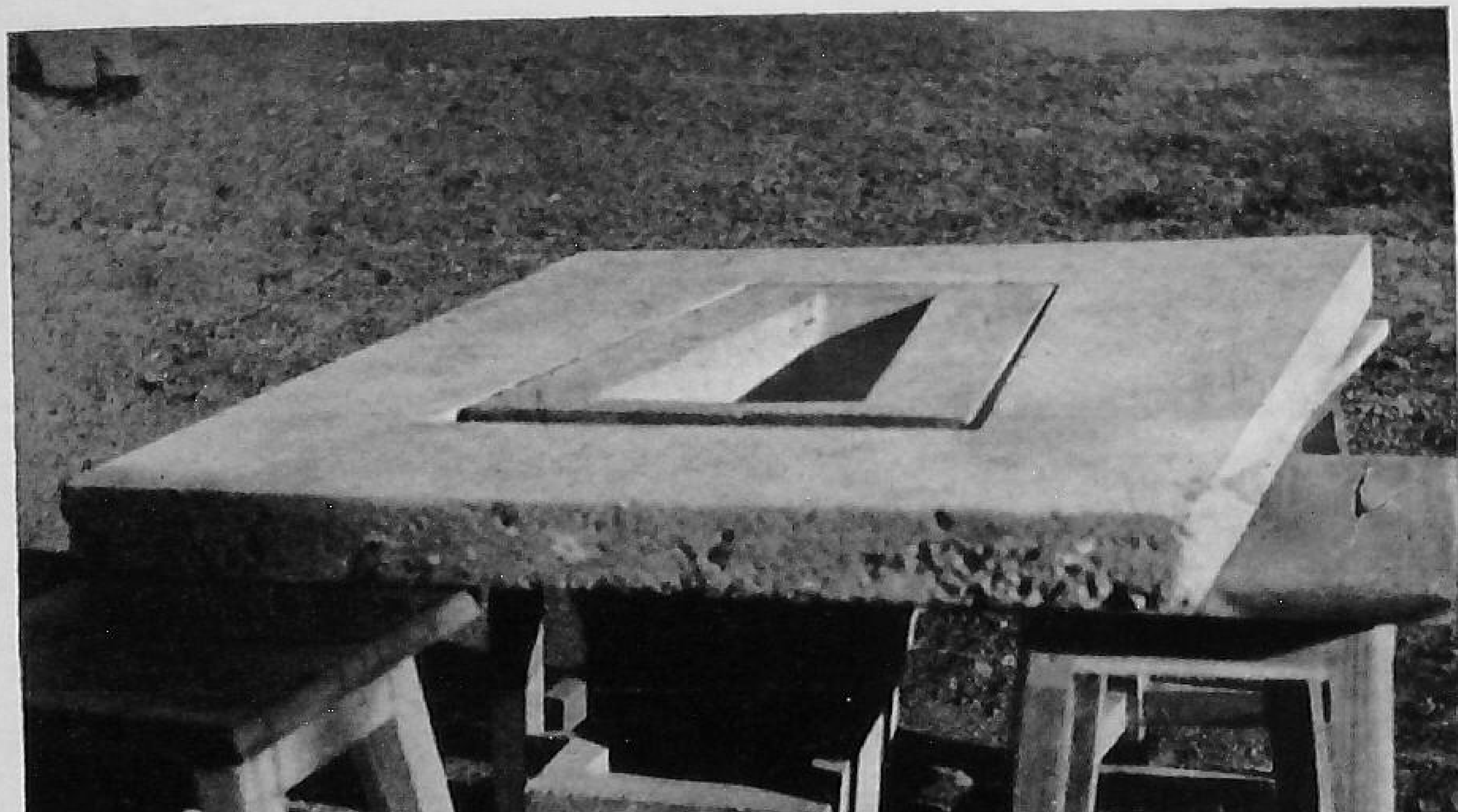
WELL LATRINE: This latrine is similar to the hand-flush

A Cattle Shed with Corrugated Tin Walls

A Cattle Shed with Brick Walls



Improved Angithies



A Squatting Plate with Water Seal

A Squatting Plate of a Bore-hole Latrine

well latrine except that the superstructure and squatting plates are not located directly over the well. One advantage of this arrangement is that when the first well becomes full, a new one can be dug nearby and the drain pipe from the water seal can be moved to discharge into the new well without moving the latrine superstructure. Another advantage of this type is that two squatting plates can drain into a single well where double latrines are used.

SIX-SEATED TRENCH LATRINE: In institutions, factories and other public places, multiple squatting plate latrines of this type may be practicable. They cost about Rs. 875 each.

SINGLE-SEATED WATER-BORNE BORE-HOLE LATRINE: The bore-hole latrine with water seal and superstructure not directly over the hole is very satisfactory where the soil is stable and rock formations are not encountered. Where the soil is unstable and the hole gets filled by caving of banks or where rock makes it impracticable to go to a depth of about 15′, another type of latrine should be selected. The offset type of bore-hole latrine does not require the moving of the superstructure after a few years when a new hole is needed. The drain from the water seal can be moved to a new hole. Such a latrine costs about Rs. 200.

BORE-HOLE LATRINE WITH SQUATTING SLAB: This is a simple latrine to construct and under proper conditions it gives reasonably satisfactory service. There is no water seal and therefore flies and mosquitoes may breed in the hole contents. However, if the hole is of maximum depth and the latrine is not used when the hole is filled up to about 5′ from the top, darkness in the hole may discourage fly and mosquito breeding. When a new hole is bored, the squatting plate and the superstructure should be moved to the new location and the old hole should be filled with earth. Such a latrine costs about Rs. 85.

DRY WELL LATRINE: The superstructure of this type of latrine may be located over about half the well. However, this involves extra cost for the concrete slab covering for the remainder of the well. This cover slab permits the removal of the contents from the well which should be avoided except

in unusual circumstances. The superstructure can be constructed directly over the well which would eliminate these features but it should be moved when a new well is needed. The water seal can be constructed from concrete and set into the squatting plate. Such a latrine costs about Rs. 140.

Water Seal Pit Latrine: This type of latrine has been especially designed for use in villages where people's income is low, and construction of other types of latrines cannot be taken in hand.

The essential sanitary features have in no case been sacrificed in this design. The major modification is in the superstructure where cheaper materials are used to replace bricks and other expensive items. The squatting slab includes a water seal of the simplest variety. This seal can be constructed of moulded clay and set into the concrete slab with very little difficulty or it can be made of concrete. Such a latrine costs Rs. 64.

Simple Bore-hole Latrine: This type of latrine has been designed to further reduce the cost of construction while maintaining adequate sanitary features. In areas where soil conditions are suitable, this bore-hole design will prove quite satisfactory. The superstructure in this case is merely to provide privacy and slight protection from the elements. It may be constructed of mud or any other material available locally. It costs about Rs. 35 only.

Further details of construction of the various types of latrines described above may be obtained from Bulletin No. 2, C.P. A. series, issued by the Community Development Ministry.

Urinals

Urinals suitable for villages can be prepared without much cost. First, a pit about 3′ × 3′ × 5′ is dug and is filled with boulders to a height of about 3′. Over this, pieces of coal are put to provide quick percolation of urine. The pit is covered with a squatting slab. A roof may be erected if necessary.

Septic Tanks

The problem of disposing of human faeces can be solved by the use of septic tanks. Here the human excreta is carried by means of water to a tank where it is digested by micro-organisms.

The principle on which the septic tank works is that under suitable conditions bacteria act upon organic material and reduce it to liquids and gases. The residue not liquefied is an inert inoffensive material. The optimum conditions for the action of the micro-organisms are: a suitable temperature, darkness and little or no agitation of the liquid to prevent aeration. To obtain these conditions a tank is constructed to hold at least 24 hours' accumulation. The standard tank has dimensions of $6' \times 3' \times 3'$. The tank is water-tight. For the successful operation of the digestion process, a chamber in which it can go on relatively undisturbed is essential. One or two baffles to prevent agitation due to incoming sewage are useful. Plenty of water is required for using the septic tank which is usually made in conjunction with flush latrines.

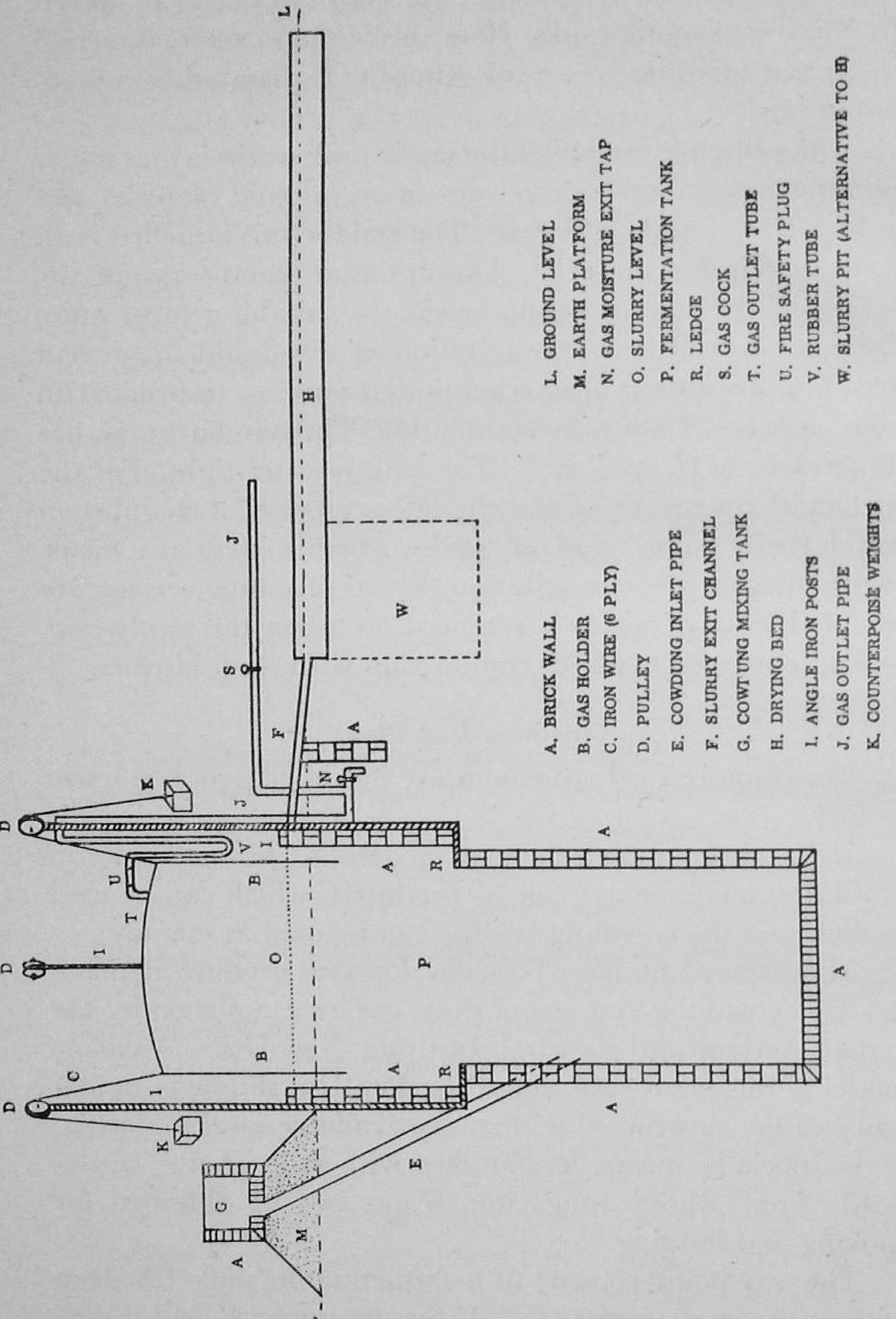
Cowdung Gas Plant

Cowdung is a valuable manure. But in villages it is burnt as fuel.

It has been found that by anaerobic fermentation of cowdung, methane gas can be produced, which can be used as fuel, and the cowdung residue can be used as manure.

Many gas plants have been developed to produce methane gas from cowdung and one of them has been designed by the Indian Agricultural Research Institute, New Delhi. A village model of this plant costs about Rs. 450. It is simple in design and can be constructed with easily available local materials. It is specially meant for families with four or five cattle-head, from whose dung enough gas can be obtained for cooking and lighting.

The gas plant consists of a fermentation tank 12′ deep with an inner diameter of 5′ 8″ for the upper 4′ and a diameter of 4′ 6″ for the lower 8′. A gas drum, 5′ in height and 4′ in diameter in which gas is collected, is suspended above



I.A.R.I. COWDUNG GAS PLANT

the tank from stilts by means of pulleys. Arrangements are made to take out the gas by a pipe and put in the slurry. Similarly an outlet for used slurry is also provided.

No extra expenditure for running the gas plant is required except that the slurry has to be put into the tank every morning.

Janata Refrigerators

India is a hot country and some kind of arrangement is necessary for storing perishable foods such as milk, curds, butter, vegetables and fruits during the summer months. The electric refrigerators used for this purpose in the Western countries are costly and cannot be used in the village homes where there is no electricity. Some institutions in India have, therefore, tried to evolve Janata refrigerators which are cheap and can be manufactured by village potters. One such model is designed on the same principle as that of a *surai* or an earthen pot where, by evaporation of water the inside temperature is lowered. It consists of an earthen vessel having two layers. Water is kept in-between these two layers. It evaporates reducing the temperature inside the pot where the perishable materials are kept. The approximate price of such a refrigerator is about Rs. 2 to 6 according to its size. It has been observed that the air inside the pot is cooler by at least 10°C than the atmospheric temperature.

The Saurashtra type Janata refrigerator is of a better design as it takes advantage of the capillary rise of water. It is claimed that in the month of May, vegetables can be kept fresh for about five to six days in this unit.

It consists of a bell shaped earthen vessel inverted in a water trough. A raised platform is provided inside the vessel to keep the perishable goods. Cloth is wrapped around the vessel and one end of it is dipped in the water in the trough. The cloth remains moist due to the capillary rise of water.

Smokeless Choolahs

To keep the kitchen free of smoke and to make maximum use of fuel, a number of ovens specially designed for the pur-

pose and suitable for a village home have been evolved. These include what are known as smokeless *choolahs* of the Allahabad type, the Hyderabad type, Magan *choolah*, etc. Of these, the Magan *choolah* has become quite popular. Wood is used as fuel in this *choolah.* Smoke is taken outside the kitchen by means of a simple chimney made of tin or earthen pipes. A special feature of this *choolah* is that it conserves and fully utilizes the heat produced by the fuel, and radiation losses are minimised. This *choolah* has three pot holes. It is provided with a damper by means of which the draught of air can be controlled.

The clay used for preparing a *choolah* should not be very plastic, and fibrous material such as horse dung or straw cuttings should be added to the clay for avoiding cracking. The rings and covers of pot-holes should be so made as to avoid leakage of smoke. The chimney joints also should be made smoke-tight.

The approximate cost of a Magan *choolah* ranges from Rs. 3 to 10 according to the size and materials used.

Efforts are also being made to devise smokeless *choolahs* useful for one or two vessels as it has been realised that farmers usually cook only one or two food materials at a time.

Where coal is cheaper, as in West Bengal, smokeless *angithis* suitable for burning coal have also been devised. They can be prepared out of cement concrete or from sheet metal. The one that is prepared from sheet metal can be used both as a *choolah* as well as an *angithi* by opening or closing the lid provided for the prupose.

The cost of such an *angithi* comes to about Rs. 3.

Chapter 23

RESEARCH, EXTENSION AND FUTURE PROSPECTS

The field of agricultural engineering in India has not yet received sufficient attention, with the result that small and cheap improved agricultural implements for some of the agricultural operations are not yet readily available. Some of the so-called improved implements have not been thoroughly tested in the field under varying conditions.

Primary importance should be given to small implements because the majority of our farmers cannot afford to purchase big and costly ones. Only a very small percentage of farmers are able to use big machines like tractors and oil engines. Because our farms are small, the financial capacity of our farmers is limited, and the only power that is available with them is either manual or bullock power. With these things in view, it is very necessary to introduce small but efficient agricultural implements in the near future.

India is a very large country and a variety of indigenous or *desi* implements are used in various parts. It is quite possible that the implements used in one part may be useful in other parts also. It is, therefore, necessary that a thorough survey of *desi* implements used all over India is made. For example, in the northern parts of India, in Uttar Pradesh, Bihar and the Punjab, the *bakhar* is not used, while it is common in Bombay, Rajasthan, Andhra Pradesh and Madhya Pradesh. This is a very useful bladed implement which can be pulled by an ordinary pair of bullocks and which can be used for cultivating, harrowing, etc. A miniature form of *bakhar* is also used for intercultivation between rows of plants. It is quite possible that this implement will get popular in other areas also.

The scope of the survey of indigenous agricultral implements should also be widened to cover not only our country, but also other countries such as Indonesia, China and

Japan, where bullock power is used. We may also find some useful implements in these countries which could be directly introduced into India. The Japanese paddy weeder is an excellent example. It was introduced into India only five years ago when the campaign for the propagation of the Japanese method of paddy cultivation was launched. It is estimated that 30,000 of these weeders are in use in the country at present, and many local firms have undertaken their manufacture. Similarly, the Burmese satoon, which is used for puddling paddy fields in Burma, has been successfully introduced in a slightly modified form into Madras.

Indian farmers have been criticised for being conservative. This is not a fair criticism as farmers all over the world are more conservative than the urban people. Indian farmers are very shrewd and understand their trade as well as their economics. Whenever improved implements have been recommended to them and whenever they have found these really useful, farmers have readily come forward to use them. In Uttar Pradesh alone, it is estimated that about 80,000 bullock-driven sugarcane crushers are in use today. These were introduced hardly two or three decades back. Similarly in Bombay, lakhs of mould-board ploughs are in use because they have been found useful for hard black cotton soils. Farmers readily take up an improvement provided it is properly placed before them.

Improvements in the indigenous or local implements should also be taken in hand. This is also economical because farmers already possess a set of *desi* implements and all that they are required to purchase is an attachment or an extra part. It should be possible to design an automatic seed-dropping mechanism which could be fixed on the *desi* plough. It is quite likely that such a mechanism will prove very popular with farmers. Efforts should also be made to improve the efficiency of the indigenous implements.

It will not be enough for us only to improve our indigenous implements or to introduce implements from foreign countries. We have to do certain amount of original research work. There is enough technical talent available in India to

conduct research in this field, and agricultural engineers in India should be encouraged to design or invent new machines.

Extension Work in Agricultural Engineering

There is a technique which should be followed by Village Level Workers to popularise improved agricultural implements. Farmers should never be approached in the fashion of an agent selling agricultural implements, because this arouses both suspicion and bad feelings. It should be made clear to farmers that Village Level Workers are not agents of any firm and that they are not doing any propaganda for sales. Farmers should be politely told that they are being approached merely for convincing them of the greater utility of improved agricultural implements.

Indian farmers have a practical bent of mind and can be readily convinced by demonstrations. The working of improved implements should be actually demonstrated under the field conditions to a group of farmers. If the farmers are convinced of the utility of the implement in the field, then many of them will go in for it. Demonstrations, therefore, should form the foundation of Extension work in the field of agricultural engineering.

Village Level Workers should, in addition to demonstrations, conduct discussions with the aid of charts, posters and cut-out models. Such lectures can be arranged at *melas* and agricultural fairs.

Village Level Workers should have complete information regarding the price of the implements, the sources of their supply and the names of the manufacturing firms, so that farmers can be given some real assistance in obtaining improved implements. This information can be obtained from the Director of Agriculture of the state concerned who maintains a list of approved firms manufacturing agricultural implements.

About 25 agricultural workshop wings have been established at various Extension Training Centres all over India for imparting training to village artisans in the repair and

manufacture of improved agricultural implements. Trained artisans from these institutions are expected to start their own workshops in villages to assist farmers in the repair of the implements as well as in the manufacture of the parts of implements. Already many village artisans have completed the course and have established their own workshops.

Village Level Workers can get their addresses from the Principals of Extension Training Centres where workshop wings are located or from the Block Development Officers and can then recommend to farmers to get their implements repaired or manufactured from these specially trained artisans. It is hoped that a large number of trained artisans will be available within the next decade or two and that they will help in introducing improved agricultural implements into rural areas.

At present we are passing through an era of development, but the speed at which we are working in the direction of introducing improved implements does not seem to be satisfactory. We will have to give greater attention to this subject in order to come on a par with other countries.

APPENDIX

THE METRIC SYSTEM

The Greek prefixes (deca, hecto, kilo, myria) denote multiplication. The Latin prefixes (deci, centi, milli) denote division.

Measures of Length

The METRE, the unit of length, originally intended to be the ten-millionth part of a line drawn from the Pole to the Equator, is now more exactly defined as the distance, at the melting point of ice, between two points on a platinumiridium bar at the International Bureau of Weights and Measures near Paris.

1 Metre	= as above	1 Decimetre	= 1/10th of a metre
1 Decametre	= 10 metres	1 Centimetre	= 1/100th of a metre
1 Hectometre	= 100 metres	1 Millimetre	= 1/1,000th of a metre
1 Kilometre	= 1,000 metres		
1 Myriametre	= 10,000 metres		

Square Measure

The ARE, the unit of surface measure, is a square the side of which is ten metres long.

1 Are	= 100 square metres	1 Deciare	= 1/10th of an are
1 Decare	= 10 ares	1 Centiare	= 1/100th of an are, or 1 square metre (metre carre)
1 Hectare	= 100 ares		

Measures of Weight

The GRAMME, the unit of weight, originally defined as the weight of a cubic centimetre of distilled water at 4° Centigrade, is 1/1,000th part of the mass of the International Prototype Kilogramme, a cylinder of platinumiridium.

1 Gramme	= as above	1 Decigramme	= 1/10th of a gramme
1 Decagramme	= 10 grammes		
1 Hectogramme	= 100 grammes	1 Centigramme	= 1/100th of a gramme
1 Kilogramme, or Kilo	= 1,000 grammes	1 Milligramme	= 1/1,000th of a gramme
1 Myriagramme	= 10,000 grammes		
1 Tonne or metric ton	= 1,000 kilos		

½ kilogramme is called a livre

Measures of Capacity, Dry and Liquid

The LITRE, the unit of the measures of capacity, dry and liquid, originally defined as the volume of a cubic decimetre, is the volume of a kilogramme of pure, air-free water at temperature of maximum density.

1 Litre	= as above	1 Decilitre	= 1/10th of a litre
1 Decalitre	= 10 litres	1 Centilitre	= 1/100th of a litre
1 Hectolitre	= 100 litres	1 Millilitre	= 1/1,000th of a litre

Metric Lineal Measures to British System

Lineal:

Millimetre	= 0.0394 inch
Centimetre	= 0.3937 inch, or less than two-fifths of an inch
Decimetre	= 3.937 inches, nearly 4 inches
Metre	= 39.3701 inches, about 3 feet 3 inches
Hectometre	= 0.0621 mile, about 1/16 of a mile
Kilometre	= 0.6214 mile, 8 kilometres=5 miles (approximately)

Square:

Centiare	= 1.196 square yards, or $1\frac{1}{5}$ square yards
Are	= 3.954 poles, $40\frac{1}{2}$ ares=1 acre (approximately)
Hectare	= 2.471 acres, nearly $2\frac{1}{2}$ acres
Square kilometre	= 0.386 square mile, or 247 acres

British Lineal Measures to Metric System

Lineal:

Inch	= 25.399 millimetres
Foot	= 30.479 centimetres
Yard	= 0.914 metre
Chain (22 yards)	= 20.116 metres
Furlong (10 chains)	= 201.164 metres
Mile	= 1.609 kilometres (5 miles=8 kilometres, nearly)

Square:

Square foot	= 9.29 square decimetres
Acre	= 0.405 hectare, or about $40\frac{1}{2}$ ares
Square mile	= 2.599 square kilometres (100 sq. miles=260 sq. kilometres, roughly)

Metric Weights to British System

Decigramme	=	1.543 grains, or about 1½ grains
Gramme	=	15.432 grains
Decagramme	=	0.353 ounce avoirdupois, about ⅜ of an ounce avoirdupois
Hectogramme	=	3.527 ounces, nearly ¼ pound
Kilogramme or kilo	=	2.2046 pounds. In trade, a kilo is reckoned at 10 per cent more than 2 pounds
Tonne or metric ton	=	2,204.6 pounds

British Weights to Metric System

Grain	=	0.0648 gramme
Ounce (avoirdupois)	=	28⅓ grammes
Pound ,,	=	454 grammes
Pound (troy)	=	373 grammes
Cwt (avoirdupois)	=	50.8 kilos
Ton	=	1016 kilos

Metric Liquid and Corn Measures to British System

Litre	=	1.76 pint (imperial), or about 1¾ pints
Hectolitre	=	22.01 gallons, or about 22 gallons

British Liquid and Corn Measures to Metric System

Pint	=	0.568 litre, or more than ½ a litre
Quart	=	1.136 litres, about 1⅛ litres
Gallon	=	4.543 litres, about 4½ litres (11 gallons=50 litres)
Peck	=	9.087 litres, about 9 litres
Bushel (8 gallons)	=	36.348 litres, about 36⅓ litres
Quarter (8 bushels)	=	2.908 hectolitres, about 3 hectolitres